Sky and TELESCOPE

Stardome on Mt. Palomar

Vol. V, No. 4
FEBRUARY, 1946
Whole Number 52
25 cents

In This Issue:

The Editors Note

TWO YEARS AGO this month, we printed the third in a series of four back-cover pictures of the moon. These were portions of plates in the Lick Observatory album of celestial photographs, and the popular demand for further lunar regions was so great that we would have gone right on with the series had the album contained more of the same. We forwarded Dr. J. H. Moore, recently retired director of Lick Observatory, copies of the many interesting letters from readers and students, all concerning these moon pictures, and he obligingly took on the task of providing additional prints. War exigencies, however, prevented completion of the project until recently, when we received, thanks to Dr. Moore and J. F. Chappell, a set of 14 prints, each 14 x 17, covering nearly the entire moon.

It is an amazing sight to see these excellently finished prints, all laid so as to overlap each other, on, say, the dining room table. They make two almost complete halves of the moon, one at first quarter and one at last quarter, each about 50 inches long, and containing a wealth of detail with good contrast. Each group of seven is made from a single negative, obtained using the visual focus of the 36-inch refractor at Lick; a wedge-shaped focal-plane shutter increased the exposure logarithmically from the limb to the terminator, thereby compensating for the decrease in the intensity of the illumination.

This month we start a series of reproductions of these moon pictures, each reduced 10 to 7 from the prints furnished us. At the conclusion of the series (which may take more than 14 months because of interruptions by other subjects of current or special interest), a mosaic about 35 inches in diameter can be made from the reproductions. When the present crisis in the paper market is over, we intend to make reprints of this set and of other back-cover subjects available to amateur astronomers.

From the vast amount of literature on the moon's features, we shall present "In Focus" items concerning the more important formations in each picture of the current lunar series.

No little of the success of these and past reproductions must be credited to the engraving department of the Union-Leader Publishing Company, Manchester, N. H., and especially to L. Strandt, head of the department, who takes a personal interest in the tricky business of reproducing our astronomical photographs. Thanks to him, the war has not affected the quality of our engravings, except for the factor of inferior paper coatings.

With this issue we return to the Adams Press, Lexington, Mass., where **Sky and Telescope** was printed for the year before June, 1944. On behalf of our readers, special thanks are due George W. McCoy, manager of the Anchor Linotype Printing Company, Boston, and his staff, for rendering good printing service under the trying conditions of the past year and a half.

Sky and TELESCOPE

CHARLES A. FEDERER, JR., *Editor*; HELEN S. FEDERER, *Managing Editor*

In Focus

ALTHOUGH the highest number in the official list of named lunar formations approved by the International Astronomical Union in 1932 is 4,789, many of the objects are subdivided into several definable parts. Nevertheless, the average amateur astronomer wishes to learn the names of some of the more conspicuous mountains, craters, and areas on the moon. Most of us will probably never be able to point out **Boguslawsky J** or **Mutus Beta**, but we would like to study the lunar surface with moderate optical aid and compare what we can see with such photographs as that on the back cover.

As a result of their compilation for I. A. U. approval, Mary A. Blagg and K Mueller published in 1935 a two-volume work, **Named Lunar Formations**, one volume comprising a series of lunar maps and the other the listing of lunar features mentioned above. In the introduction to this publication, selenographers are asked to adhere strictly to the approved names, and to give no new name to a formation already bearing one.

There are now a total of 672 separate names for lunar features, of which 609 are personal names. This information appears in another interesting work, **Who's Who in the Moon**, Vol. 34, Part 1, of the **Memoirs** of the British Astronomical Association, published in 1938. Here we find such information as that Palon Heinrich Ludwig von Boguslawsky (1789-1851) was an artillery officer in the Prussian army, born in Magdeburg, who was appointed director of the Breslau Observatory. His son wrote on comets and meteors. The lunar formation was named after him by Maedler.

The Blagg-Mueller list includes the selenographic co-ordinates of the central point of each feature; no objects are included which are not clearly visible in good photographs, or which measure less in apparent diameter than 1/500 of the semidiameter of the moon's disk. The difference between eminences and depressions is indicated, and the character of each formation designated. This classification includes valleys; rills and clefts; single hills and peaks; ridges, chains, and plateaus; maria or seas; confluent twin craters; irregular and indistinctly walled plains; bays, gulfs, and formations not fully enclosed; and finally, walled craters, holes, and ring plains.

(*Continued on page* 20)

VOL. V, NO. 4
Whole Number 52

FEBRUARY, 1946

CONTENTS

COVER: The 137-foot dome of the 200-inch telescope on Mt. Palomar, photographed in 1940 by L. S. Copeland. (See page 3.)

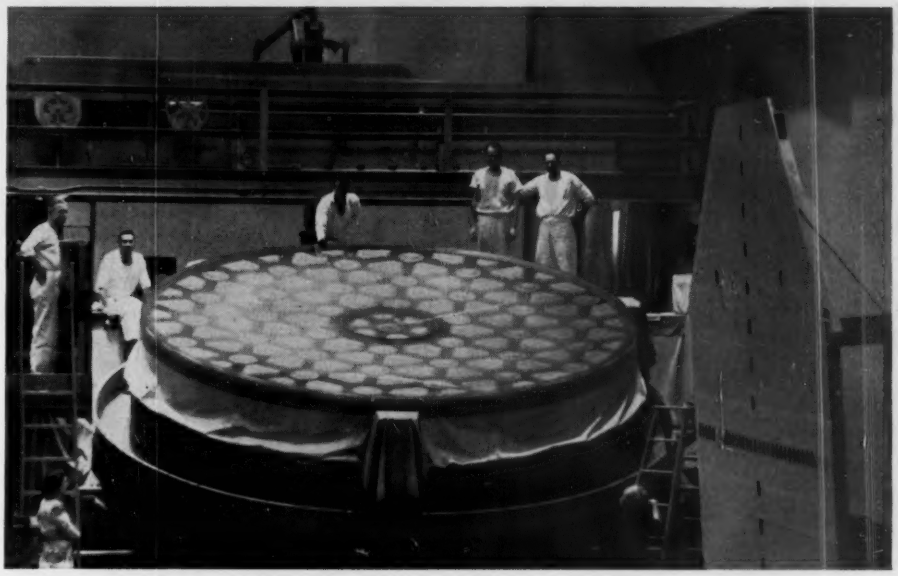
BACK COVER: A portion of the southwestern edge of the moon near first quarter, from a Lick Observatory photograph taken with the 36-inch refractor by J. H. Moore and J. F. Chappell. The reproduction is reduced 10 to 7 from a 7.8 enlargement of the original negative. (See The Editors Note and In Focus.)

SKY AND TELESCOPE is published monthly by Sky Publishing Corporation, Harvard College Observatory, Cambridge 38, Mass. Entered as second class matter, April 28, 1939, at the Post Office, Boston, Mass., under Act of March 3, 1879; accepted for mailing at the special rate of postage provided in Paragraph 4, Section 538, Postal Laws and Regulations.

Subscriptions: $2.50 per year in the United States and possessions, and to members of the armed services; Canada and all countries in the Pan-American Postal Union, $3.00; all other foreign countries, $3.50. Make checks and money orders payable to Sky Publishing Corporation. Send notice of change of address 10 days in advance. Circulation manager: Betty G. Dodd.

Editorial and general offices: Harvard College Observatory, Cambridge 38, Mass. Unsolicited articles and pictures are welcome, but we cannot guarantee prompt editorial attention, nor are we responsible for the return of unsolicited manuscripts unless return postage is provided by the author.

Advertising director: Fred B. Trimm, 19 East 48th Street, New York 17, N. Y.; ELdorado 5-5750.



A recent photograph of the 200-inch mirror, nearing completion in the Caltech optical shop at Pasadena. Of the original 21 "men in white," only two have so far returned from war work, and appear here among the five who have taken up the big task. Photograph by the Los Angeles "Times."

The Eye That Will Look for the Uttermost

By Leland S. Copeland

EARLY in 1947 the 200-inch telescope will begin to scan the deeper depths of heaven. At that time astronomers will inaugurate a search that will give to the world new insight into the secrets of the greater suns and of the metagalaxy. Probably they will be able to verify or disprove recent cosmological theories. But they also may discover new facts suggesting ideas that never before have entered into the mind of man.

Before another year begins, the great mirror probably will have been polished to within two millionths of an inch of perfection and will be ready for its berth in the intricate mounting. But another five months may pass before all accessories and adjustments have been completed. So a total of 19 years, including the war recess, will have gone by before the vast project, started by Dr. George Ellery Hale, can be accomplished and search begun for "buried treasures" on the frontiers of space and time.

Plans are being worked out for a union of two of the three great observatories founded by Hale. Mount Wilson, home of the 100-inch telescope which has contributed so gloriously toward the solution of ultimate mysteries, and Palomar probably will become a single institution, with one outpost on Mt. Wilson, a few miles north of Pasadena, and the other on Palomar tableland, 125 miles to the south and 30 miles from the ocean.

Some Pasadena astronomers hope that the home of the 200-inch will be called Hale Observatory. Palomar is a musical and high-sounding word in English, but in Spanish it means only pigeon house or dovecot. This name was given to the long mountain because band-tailed pigeons used to frequent it. But perhaps you will think it an odd word for the world's greatest stardome.

Through failure to select a more appropriate designation for Mount Wilson Observatory, that great stellar laboratory became a memorial to Benjamin D. Wilson, owner of a huge ranch and founder of Alhambra, Cal. The pioneer investor's name has become known throughout the intellectual world because he obtained as site for a resort hotel a mountain summit that later appealed to astronomers.

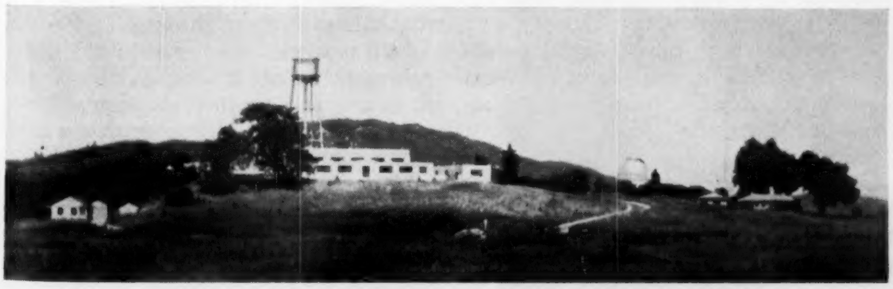
When the average person talks about the 200-inch telescope, he is likely to say, "I'd sure get a thrill looking through that instrument. They say it'll bring the moon within 25 miles of us. And wouldn't it be great to see the canals of Mars?" But Mr. Average Person is here like the man who leans forward to see the mayor of his city when the president of the United States is passing by. The glass giant will be reserved for other business. Though telescopes do not have watchwords, a good motto for the 200-inch could be found phrased in the first chapter of *The Acts of the Apostles,* "To the Uttermost."

"The telescope," explains Dr. John A. Anderson, of California Institute of Technology, who is chief of the project, "will not be used for work that can be done equally well by existing instruments. Always the object will be to reserve it for those observations which require its greater light-gathering power: first, for large-scale spectroscopic work on the brighter stars, and, second, for a study of the very faintest extragalactic nebulae."

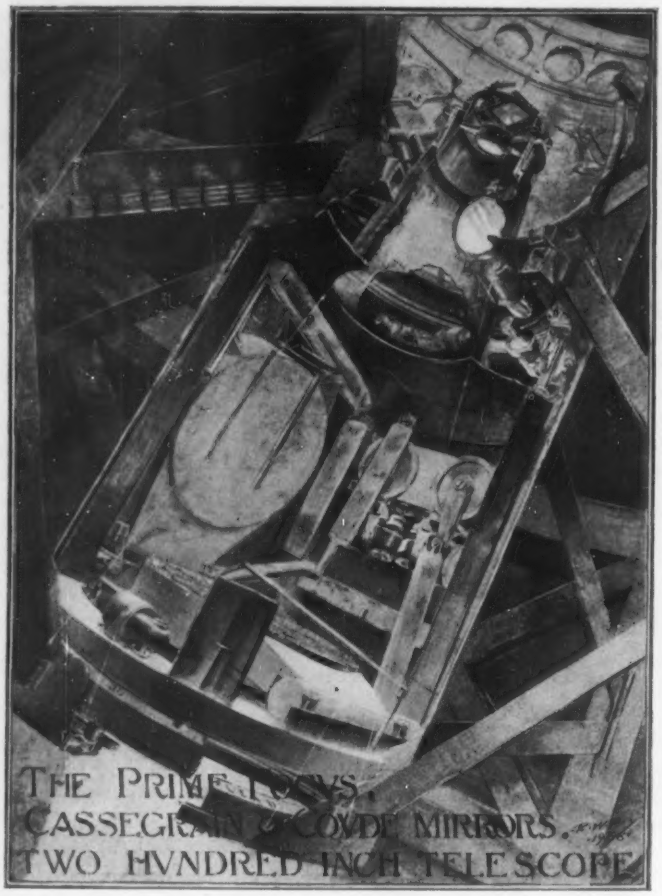
And so the moon and the planets, dear to the hearts of amateurs, will have to be by-passed. For news of our nearest neighbors in space we must look to other observatories. But wait, there will be at least one exception. Russell W. Porter, architect of Palomar Observatory, has been promised his hour under an eyepiece of the 200-inch while it is pointed at the moon. He will make pencil sketches of lunar marvels and try to record details so delicate that ordinarily they escape the grasp of photographic plates.

In revealing this arrangement, Mr. Porter, sometime shepherd of amateur astronomers and co-promoter of the present-day amateur mirror making hobby, lifted his pipe from his mouth and smiled. He continued:

"One night when Mars was at its



Utility Hill, showing the power house in front of the water tank. On the right, beyond a fragment of road, is the dome of the 48-inch Schmidt telescope. At the extreme right, below the trees, stand two buildings of the hospitality and dormitory center. In the background rises one of the summits of Palomar Mountain. Photo by the author.



One of the graphic Porter cutaway drawings of the 200 - inch telescope shows two of the three auxiliary mirrors, and mechanisms for swinging them into and out of position. With the mirrors swung back against the cylinder, the way is clear for the light path from the mirror to the prime focus above. The prime-focus housing is large enough for the observer to "ride" inside.

best, Milton Humason called me to Mount Wilson Observatory. Leading me to a telescope, he said, 'I want you to draw whatever you can see tonight.' When I returned to Pasadena, I handed my sketch to the chief, Dr. W. S. Adams.

"'Here it is,' I remarked, 'but I haven't shown any canals. So throw it into the wastebasket if you wish.' And Dr. Adams replied, 'That's why we want to keep it; we're going to frame it.'"

Mr. Porter explained that Mount Wilson astronomers have not been able to see the canals, but he added that there is truth in the argument that small telescopes, in brief moments of atmospheric clearness, can reveal planetary details not observable through larger instruments.

Meantime, the latest event on the Palomar calendar was the reopening of the observatory grounds on January 1, 1946. The gates had been closed to visitors because of the war. But through the months of waiting the caretakers of the great instrument did not fail to oil it faithfully. And about every two weeks they moved it a little to keep it in condition.

The 1946 sight-seer will ascend Palomar Mountain by a wide high-gear road, built for the astronomers by the supervisors of San Diego County. Through evergreens and golden oaks the smooth ascent winds gracefully until the visitor can spy, on a summit ahead, an apparently tiny tower, the mighty stardome. A few more miles, a few more easy curves, and the sight-seer will be at the observatory gate.

Entering the grounds through a high fence, the visitor will follow a wide pathway to the museum, a low-slung building of modernistic design. This attraction is not yet ready for guests. But in time it will display transparencies of celestial marvels, photographed at Mount Wilson and Palomar, and perhaps models of the telescope and the grounds. It will serve also as a lecture room whenever occasion requires. Here, too, may be a visitors' register, to satisfy the irresistible human longing to write names on lofty places.

The sight-seer, leaving the museum, will continue up the pathway to the largest of the three domes. The home of the 200-inch is a mammoth laboratory, 137 feet by 137, but it looks small in its grandly spacious surroundings, the focal point of 1,960 acres comprising the astronomers' estate.

Albert G. Ingalls, *Scientific American* editor, noticed that the big observatory was only about three feet smaller than the Pantheon in Rome. Though this comparison does not help us picture the size of the stardome, because few of us have visited Rome, it does link the 20th century neatly to the 2nd. The Pantheon was, according to Byron, "shrine of all saints and temple of all gods"; the observatory, though it will receive messages from beyond the seventh heaven of the ancients, will be strictly a place of business. So guests should be careful, when talking with the "watchers," not to call the huge building a 12-story temple, because to such poetry the astronomers might answer, "Bosh."

The sight-seer approaching the stardome will ascend the path to a short granite stairway leading to the main door. Entering and passing through a vestibule, with a big decorative star on the floor, he will go up nearly 50 steps. He will emerge in a large enclosed visitors' room. Through a transparent wall he will see the telescope standing in the huge circular room that only astronomers may enter.

Yes, there it towers — the great tube 60 feet long and 22 feet in diameter, weighing 120 tons, and inside, out of sight, a concrete block doing duty for the 14½-ton mirror that is approaching perfection in the Caltech optical shop in Pasadena. The tall telescope is waiting for the day when it will have an eyepower of nearly 1,000,000.

As no lights can be on at night in the visitors' room, all sight-seeing must be limited to daylight hours.

After leaving the major attraction, the visitor may wish to observe the scenery. From the catwalk aloft, around the big dome, one can glimpse Lake Elsinore, Catalina Island, Mt. Wilson and Old Baldy in the Sierra Madre chain, and, on rare clear days, even the far-off High Sierras. But "the view from the low hill a few hundred feet from the dome, to the northwest, is every bit as good," Dr. Anderson reports.

The small Palomar community, 5,600 feet above the sea, has its own gas, light, water, and telephone systems, centering on a mound that David O. Woodbury calls Utility Hill.

The great astronomical adventure began in April, 1928, when *Harper's Magazine* published an article, "The Possibilities of Large Telescopes," by Dr. Hale.

"If the cost of gathering celestial treasure," he wrote, "exceeds that of searching for the buried chests of a Morgan or a Flint, the expectation of a rich return is surely greater. . . . The latest explorers have worked beyond . . . the Milky Way in the realm of spiral 'island universes'. . . . As there is every reason to believe that a suitable Pyrex or quartz disk could be successfully cast and annealed . . . I believe that a 200-inch or even a 300-inch telescope could now be built."

After $6,000,000 for a 200-inch project had been granted to California Institute of Technology by the Rockefeller General Education Board, experimentation began, in 1929, on the production of large fused quartz disks. The work was done in Lynn, Mass., by the General Electric Company.

In charge was Prof. Elihu Thomson,

inventor and executive, who, as a young man in the 1880's, had made a 3-inch refractor and inspired many of his fellow amateur enthusiasts to make refractors varying from two to four inches in aperture. (The story can be found in The SKY of September, 1940.)

Prof. Thomson was an ardent advocate of quartz for telescope mirrors. In 1929, 1930, and 1931, he and his assistants vainly toiled to realize his dream. Their first 60-inch disk cracked, and the second was ruined when a fragment of furnace brick dropped into the molten mass. An attempt to fill the crack in the first block was almost successful, but by mischance the electric current was turned off and the crack widened until the disk was wrecked. By that time $600,000 had been spent; so the Pasadena astronomers voted for super-Pyrex glass.

In charge of the venture at Corning, N. Y., was George V. McCauley. An experimental solid 26-inch block was made first; then the 30-inch ribbed Coude disk was completed successfully on the third trial.

When the 60-inch Cassegrain mirror was poured, rising cores ruined the first attempt, as they had the first Coude disk. During casting of the second block, only one core broke loose. The workers angled it out, and later the resulting solid place in the ribbed back was removed with a grinding wheel.

Before the next pouring day metal rods were added to fasten down hollow cores. The resulting 120-inch was perfect. So the score at Corning read: two years (1932-1933), three satisfactory disks.

The first 200-inch was poured, while thousands of visitors watched, on Sunday, March 25, 1934. Several cores emerged. These the workmen shattered with long bars, but McCauley decided to try again. After tubes had been introduced to carry cool air around the metal bolts, the second 200-inch was ladled in on Sunday, December 2, 1934. For two months it remained at constant temperature; then for another eight months it slowly cooled. Meantime, a flood in near-by Chemung River nearly ruined it by attacking the electric equipment that kept the annealer warm. For 72 hours the heat was off, but the glass giant remained unharmed.

While the 200-inch was waiting in a steel case between the factory and the river, the water rose again. But the glass was removed 48 hours ahead of the deluge, after a corner of the factory, barring the way, had been broken down.

How in March and April, 1936, the great eye was shipped to California; how Capt. Clyde S. McDowell was released by the U. S. Navy to superintend the construction of the telescope mounting; how seemingly insolvable problems were mastered in designing the yoke, the bearings, and the controls; how the horseshoe of the yoke, biggest bearing ever built, was manufactured by the Westinghouse Company in South Philadelphia and Pittsburgh and assembled in South Philadelphia for a trip through the Panama Canal; how Sinclair Smith elaborated the amazing control system and refused to let illness halt his studies, which ended only when death took him; how the disk was ground and polished by Marcus H. Brown and 21 men in white — all these things and many other entertaining details have been told, as probably no one ever will be able to tell them better, by David O. Woodbury. Mr. Woodbury's *Glass Giant of Palomar* is more absorbing than a romance, as it unfolds an epic of men triumphing over disappointment and super-difficulties.

The world's greatest telescope is such an intricate instrument that only experts, after study, can understand it intimately. As an aid toward comprehension of its major details, the 10th-scale model in Pasadena is most helpful. It stands on the sun-roof of the astrophysical laboratory, separated by a long line of buildings from the optical shop, in which the 200-inch was ground and is being polished.

Indeed, the Little Giant is just what all amateurs would like to own and use, except for the construction price and the taxes that city and county governments might exact.

"It cost pretty high," Dr. Anderson said in answer to a question, "but it was necessary to have it. It can be used for astronomical work, but needs to be overhauled for this purpose. We built it to make mechanical tests for use in designing the big one."

The dome of the Little Giant is lined with cork, covered with aluminum paint. The shutter must be opened by hand, but other controls in the home of "the guinea pig" are electrical.

Right ascension and declination indicators are not engraved on the axis wheels, but appear as illuminated dials on the wall of the little observatory. The telescope has two gaits, tracking and sluing. When sluing is used, the black second hand spins rapidly around, but when tracking is in operation the second hand moves with leisurely pace.

The astronomer in charge holds a small, short cylinder at the end of an electric cord. On this cylinder are four control buttons, two for right ascension (east and west movements) and two for declination (north and south). Between the pairs are tiny round projections, like those on an electric heating pad, guides to the buttons, so that an observer can operate the controls in the dark.

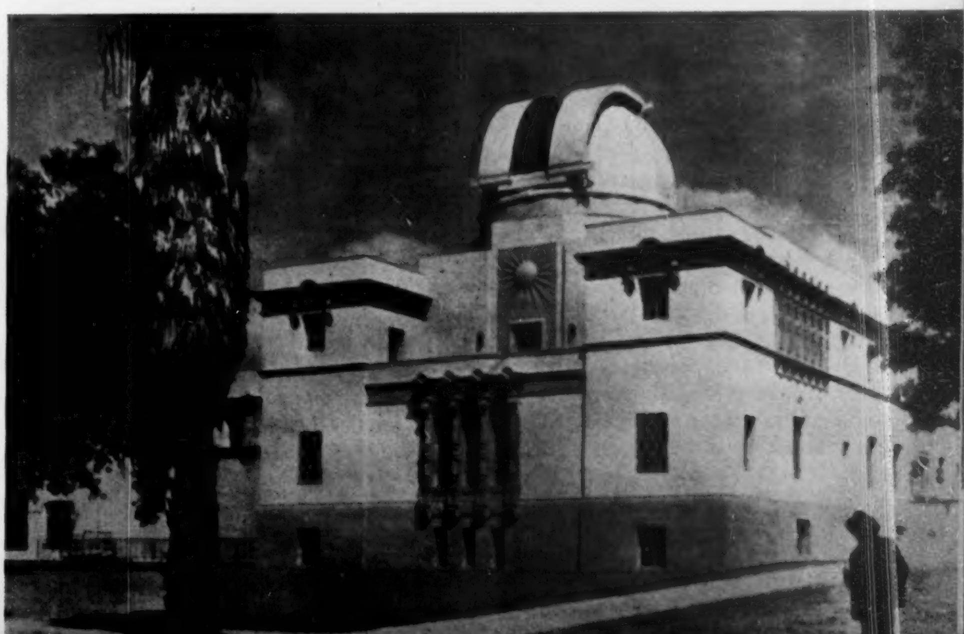
For the first time in astronomical history, a dome slot keeps pace automatically with a telescope tube. In a small near-by building are a miniature observatory shutter and a miniature telescope tube, reproducing the movements of their counterparts in the dome. When the midget shutter makes electric contact with the midget tube, the Little Giant's roof moves over to give an unobstructed outlook to the telescope.

Under the horseshoe of the 10th-scale model can be seen two boxes containing the oil-pad bearings. To each box climb two pipes holding oil at 50 pounds' pressure when the telescope is in use.

These arrangements will be reproduced in the great stardome at Palomar. Like the dinosaurs of Mesozoic times, the titan-telescope will have two brains. One, the control panel, stands in front of the polar axis, between the north piers. Its indicators will show sidereal and Pacific standard time, zenith angle, right ascension and declination, and the position of the wind screen. Here also are dials for setting the place to which the telescope will be directed next. In the case behind the panel are computers for correcting atmospheric refraction and small deformations of the telescope itself. These computers are two-dimensional cams, one for right ascension and one for declination. To an amateur they look like bottles with bent-in sides.

At the back of the case are two steel

The astrophysical laboratory of the California Institute of Technology, where the 10th-scale model of the 200-inch is located.



arcs, one for tracking the telescope and one for sluing. A $\frac{1}{2}$-horsepower motor controls tracking, and a 2-horsepower motor governs sluing and setting.

The second brain will be on the mezzanine floor. There probably will be the clocks for sidereal and Pacific standard time, and there may be the dummy telescope tube and midget shutter for regulating automatically the position of the dome slot and for finding the zenith angle.

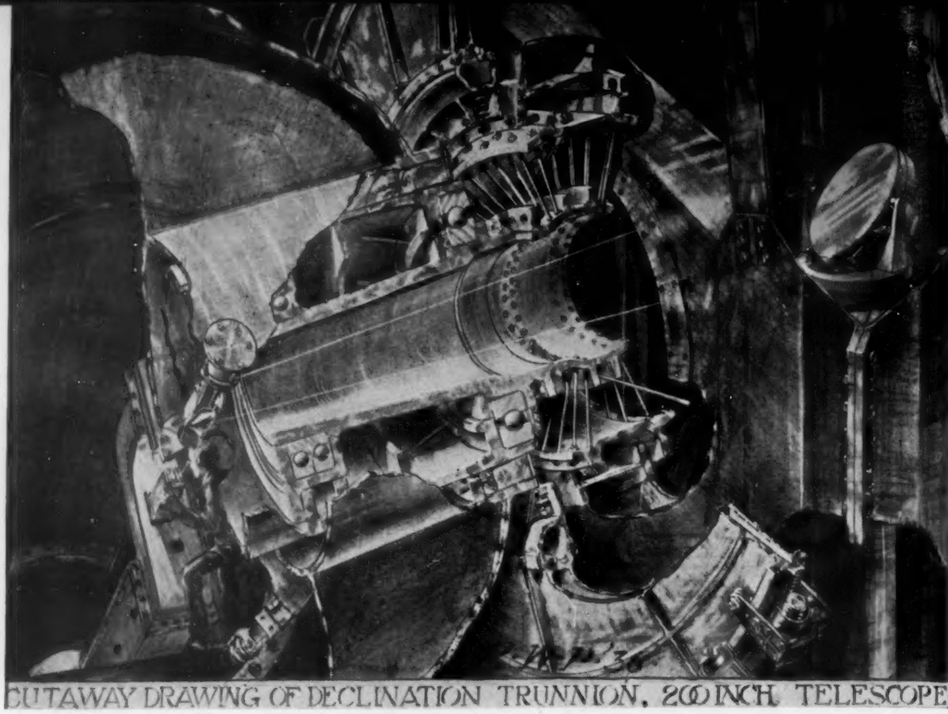
At every focus of the great instrument will be illuminated dials showing the position of the telescopic field in right ascension and declination; also electric control buttons, the fast and slow motion controls.

At four places light can be brought to a focus — in the cartridge room suspended in the mouth of the tube (prime), at the bottom of the tube (Cassegrain), inside one of the yoke arms (Coude) and at the lower end of the south axis (Coude). Those that in practice give the best results will be used regularly, especially the prime focus and the focus either in the yoke arm or at the south axial end.

When observers enter the yoke-arm room, a compensating device will keep the telescope in balance. And elsewhere, whenever weights are introduced, counter-pressures are brought into play.

While the gigantic telescope has been under construction, at least three men who greatly helped to make it a reality have been taken by death. These saw the promised land from afar — Dr. Hale, Dr. Smith, deviser of the central control system, and Dr. F. G. Pease, who designed the rib structure and the ball-bearing equipment. Pasadena astronomers greatly regret that these men, who dreamed so resultfully and worked so patiently, did not live to learn of the greater knowledge that soon may be the property of common minds.

What poets and prophets groped to find, what philosophers and theorists strained to precomprehend, soon may be revealed to untrammeled minds of Planet Three. For the long, long period of study, experimentation, and painstaking labor is nearly at an end.



CUTAWAY DRAWING OF DECLINATION TRUNNION, 200 INCH TELESCOPE

Suspended in one of the 10-foot tubes of the 200-inch yoke is an 8-foot plane spectrograph (shown with an observer in this Porter drawing), which can receive starlight from the Cassegrainian secondary and a diagonal flat, here visible at the extreme right. Note the "bicycle spokes" supporting the declination trunnion.

ASTRONOMICAL ANECDOTES

ASSASSINATION, BAYS, AND SHADOWS

ABOUT 1333, at Kesh, was born Timur i Leng (Timur the Lame), better known as Tamerlane; he died in 1405. He had tuberculosis of the knee, which made his right leg shorter than the left. In a huge mausoleum in Samarkand, his body has recently been found by Soviet scientists; the body, wrapped in cloth of gold and silver, was lying in an ebony coffin protected by two-ton stone slabs.

Two other bodies, of his sons Miran Shah and Shah-Rukh, lay at his side. At his feet lay yet another, this one with the head severed. This was all that remained of the greatest astronomer — at least the greatest observer — from Ptolemy to Regiomontanus. He made a catalogue of stars from original observations from his massive observatory, also now found in Samarkand.

This was Ulugh Bey, who was born in 1394, a grandson of Tamerlane. Some time after 1420, when he built his observatory, he compiled the catalogue and his new tables of the motions of the planets. He was ruler in Samarkand and last of the Arab astronomers. In 1449 his son, Abdu el Latif, hired an assassin to kill Ulugh Bey, and the body as now found reveals the manner of his death as history has chronicled it.

A press clipping from Pittsburgh, two days after Christmas, has made it necessary for me to say a little more about the Carolina bays. According to Dr. Nelson H. Darton, who retired from the U. S. Geological Survey 10 years ago at the age of 71, "Arizona's famous crater, usually referred to as Meteor Crater, was not caused by the impact of an enormous projectile from outer space at all."

Reading again of the steam-explosion hypothesis first proposed by G. K. Gilbert, of the Geological Survey, seems a little retrogressive, in 1946. Some early writers in the Geological Survey also supported the theory of meteoritic origin of the bays, where no meteorites are found; now we find one who denies the meteoritic character of the Arizona crater where perhaps 15 tons of meteorites have been found.

Dr. Darton bases his renewal of the old statement on the insufficient arguments that the great meteoritic mass searched for (he says at a cost of more than $1,500,000, which seems rather high) has never been found and that there are genuine volcanic craters in Arizona. Dr. Darton believes the crater was produced by a steam explosion, and it was he who gave the formation the name "Crater Mound," officially adopted by the U.S. Board of Geographic Names. Nevertheless, the National Geographic Society maps, in 1940, used the names "Meteor Mountain" and "Meteor Crater." I hardly think the Board of Geographic Names means to imply denial of the meteoric origin simply by its approval of the name.

What we should do is to banish steam-crater adherents to the adust regions of the amphiscians. As ascians, they would then be set apart from us wiser folk who call ourselves heteroscians, except at this time of year, when we might as well be periscians. These good dictionary words are all in a little book: "An Introduction to Geography, Astronomy and Dialling, containing the Most Useful Elements of the said Sciences, adapted to the Meanest Capacity, etc., etc.," by George Gordon, at London, 1726.

Translations: *adust* is hot; *amphiscians* or *ascians* are inhabitants of the torrid zones; *heteroscians* are those who

(*Continued on page* 22)

NEWS NOTES

By Dorrit Hoffleit

VARIABLES IN GLOBULAR CLUSTERS

Dr. Helen Sawyer Hogg, of the David Dunlap Observatory, has probably done more work on globular clusters and completed more periods for the variable stars they contain than has any other astronomer. Four contributions by her have recently been received. In one she suggests, on the basis of the distances of the clusters deduced from her periods and the period-luminosity relation, that the center of our Milky Way system may be much closer than previously supposed. The usually accepted value is 10,000 parsecs (32,500 light-years) whereas her data indicate that it may not be more than 8,000 parsecs to the galactic center.

Another result of great interest is the frequency array of periods of the variables in different clusters. In some, the average period is half a day and the frequency distribution has but a single maximum. In other clusters, two maxima are found, one corresponding to periods around one third of a day and the other to periods around two thirds. In these cases there are very few periods, if any, in between at the half-day period common in the other clusters. Accidental observational selection (incompleteness of discovery of such stars) is unlikely to have affected the conclusions. The reason for the two distinct kinds of variable star distributions has not yet been ascertained, but the facts are undoubtedly of cosmological significance.

COMET DU TOIT (1945f)

On the basis of observations from December 11th to 15th, transmitted by Dr. J. S. Paraskevopoulos, of the Boyden station of Harvard Observatory, Dr. Leland E. Cunningham has computed three possible orbits for the third comet discovered by D. du Toit in 1945. (See page 17, January *Sky and Telescope.*) The resulting predicted positions for January all placed the comet too far south for detection by observers in the United States. Dr. Cunningham writes:

"On the day of perihelion passage (December 28th) the comet may have been a brilliant, naked-eye object within a couple of degrees of the sun. It may have passed behind the sun, and so have been within reach of coronagraphs just before and after occultation. But these passages probably occurred at the wrong times of day for any known station."

Dr. Fred L. Whipple, of Harvard, has pointed out the similarity of the Cunningham orbits to those of the group that includes Comets 1668, 1843 I, 1880 I, 1882 II, and 1887 I. Some of these passed so close to the sun that they were broken apart; all were exceptionally bright, and they may be the fragments of a single comet which disrupted centuries ago.

The observations reported for Comet du Toit, however, are scanty, so the orbital elements are still uncertain. Further information depends on the rediscovery of the comet as it leaves the vicinity of the sun.

RADIAL VELOCITIES COMPLETED

Dr. R. K. Young, who retired on January 1st as director of David Dunlap Observatory, University of Toronto, has recently published a catalogue of radial velocities of 681 stars. The list includes all stars in the northern hemisphere brighter than magnitude 8.0 photographic, and of spectral types *A0* to *M*, for which no previous radial velocities had been available. This is welcome new data for students of stellar motions and local galactic structure.

Successor to Dr. Young is Dr. Frank S. Hogg, who is made professor and head of the department of astronomy as well as director of the observatory.

MAN-MADE COSMIC RAYS

A 4,000-ton cyclotron, to be completed next summer at the University of California, is expected to permit, for the first time, "the artificial production of cosmic rays, the obtaining of atomic energy from cheaper sources than uranium, and the discovery of many new elements," Science Service reports.

Professor E. O. Lawrence, Nobel prize winner, is in charge of the work on the new 184-inch cyclotron, which is five times more powerful than the 60-inch apparatus employed in atomic-bomb research. He predicts that the enormous energies which will be achieved will make practical the heretofore impossible testing of many theories of atomic structure. Cosmic rays, believed to result from explosions in nature, releasing atomic energy, will be subject to much more systematic investigation when their energies are equaled in laboratory experiments.

ELEMENTS 95 AND 96

From *Science* we learn that element 95 has been produced by bombarding uranium (element 93) with alpha particles, and element 96 has resulted from a similar bombardment of plutonium (element 94). Drs. Glenn T. Seaborg and Joseph G. Hamilton, of the University of California at Berkeley, report that the 60-inch cyclotron in the Radiation Laboratory there has been entirely rebuilt by the group of scientists at the Crocker Laboratory. When put back into operation in January a year ago, the cyclotron could produce deuterons and alpha particles at measured energies of 20 and 40 million electron volts, respectively.

The identity of the two new elements was established by their chemical and radioactive properties, work which was done by the chemistry group at the Metallurgical Laboratory at the University of Chicago, where Dr. Seaborg is at present stationed.

As there are no more distant planets known than Neptune and Pluto, astronomy may be said to handicap naming of the new elements. Dr. Seaborg has received many suggestions; we offer another: the planetoids, from which there are many names to choose.

DEATHS OF PRISONERS OF WAR

Through Dr. G. van der Bilt, of the University of Utrecht, Dr. Peter van de Kamp reports the deaths of three Dutch astronomers, all from exhaustion as Japanese prisoners of war in the Netherlands East Indies. They were Dr. Arnout de Sitter, acting director of Bosscha Observatory, Lembang, Java, and son of the famous W. de Sitter; Dr. W. Chr. Martin, also of Bosscha Observatory; and J. Uitterdyk, of Batavia.

GENERAL PATTON'S BIRTHPLACE

Among the writeups of Gen. George Patton's life, we find the following, from the Los Angeles *Times*:

"The general was born on the ranch [San Marino], Nov. 11, 1885, in a house built by Don Benito Wilson, for whom famous Mount Wilson Observatory is named."

That was before San Marino was incorporated; the ranch was called Lake Vineyard Ranch.

COURSES FOR THE PUBLIC

New courses in astronomy and navigation have been announced by the Hayden Planetarium in New York City. Of special interest to parents is a series of talks on astronomy for young people which starts on February 2nd, and continues thereafter on alternate Saturdays, at 10:00 a.m. There will be eight half-hour sessions, in the planetarium chamber, conducted by Catharine E. Barry.

"Modern Celestial Navigation," by Curator Gordon A. Atwater; "Astronomy Without Mathematics," by Robert R. Coles; "Stars and Constellations," by Marian Lockwood, are the titles of the other courses. Write to the Hayden Planetarium, 81st Street and Central Park West, New York 24, N.Y., or call ENdicott 2-8500, for more detailed information.

Cosmogonical Implications of the Atomic Bomb—IV

By Felix Cernuschi, *Guggenheim Fellow at Harvard University*

11. The neutron in astrophysics

As is well known, outstanding work has been done by Eddington[20] in connection with the internal constitution of the stars, and this work was considerably extended and modified by Milne, Russell, Chandrasekhar, and others. These men have succeeded in an amazing way in correlating some of the important observational features of the stars, but there are still some aspects of stellar behavior which do not have completely satisfactory explanations.

It is not our purpose here to criticize or present an analysis of the abovementioned existing theories, thanks to which we have a clear understanding of how nature works, in many respects, in remote regions of our universe, under conditions generally completely different from those existing on our planet. These theories, no doubt, represent one of the greatest conquests by the human mind. But as science always leaves room for new or modified hypotheses, the following ideas may indicate ways in which we can account for some of the facts about the stars which present theories do not clearly explain.

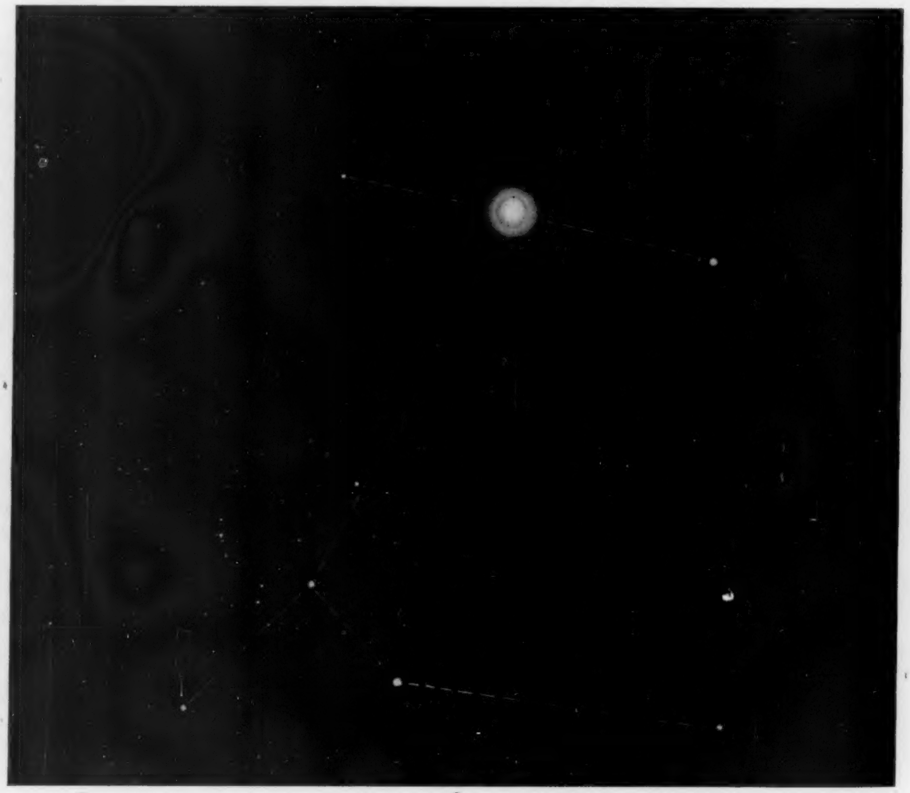
In what follows from here to the conclusion of this series of articles, the reader not familiar with the physics terminology used will do well to review the earlier installments concerning nuclear physics and the atomic bomb, to review W. F. G. Swann's article on cosmic rays (*Sky and Telescope,* May-August, 1944), in which is found a description of many of the fundamental particles of physics, and to refer to such books as *Astronomy,* Vol. II, by Russell, Dugan and Stewart. In no case do we attempt to give a rigorous mathematical or theoretical presentation, and working formulae and numerical calculations may be found in the bibliographical references. Also, the bibliography serves to supplement our necessarily limited consideration of the many theories concerned in the subjects under discussion.

The first to introduce neutrons into astrophysics was Kothari,[21] to explain the high densities of the white dwarfs. As is reported in our textbooks, W. S. Adams, by a very careful spectroscopic analysis, found that the companion of Sirius, already known to have a mass a little less than that of the sun, has a surface temperature of about 8,000° centigrade. As this is hotter than the sun's surface, the star's radiation per unit area must be greater, but its total luminosity is only about 1/350 that of the sun. Therefore, its surface area must be small; the star turns out to be about as large as the planet Neptune. But since its mass nearly equals the sun's, it is found to have an average density about 50,000 times that of water. Other white dwarfs have been discovered with mean densities as high as several hundred thousand times that of water, and, in 1935, Kuiper[22] discovered a white dwarf which has the following characteristics: surface temperature 28,000°, diameter roughly half that of the earth, calculated mass about 2.8 sun's, to which corresponds an average density about 36,000,000 times that of water. This star's central density is of the order of magnitude of 900,000,000, or nearly a trillion times as dense as water! We shall refer to this "abnormal" white dwarf later.

In general, the equilibrium of a star is maintained by the balance between gravitational pressure inward and the outward forces resulting from radiation pressure and from the thermal agitation of the particles of matter inside the star. The higher the internal temperature, the greater the radiation pressure and the velocities of the ionized atoms and free electrons which are the principal constituents of the normal stellar interior, and the greater the tendency of the star to expand. Theories of the internal constitution of the stars try to achieve, according to known physical laws, density distribution of the matter inside the stars in such a way as to satisfy their three observable characteristics: mass, luminosity, and temperature.

In the white dwarfs, the outward pressure of light, electrons, and atoms must allow for an internal distribution of mass to the high order of density required in these stars. Unless unreasonable hypotheses are assumed, gaseous stars obeying the perfect gas laws cannot reach these densities. Fowler[23] was the first to point out that Eddington's model of a gaseous star most probably could not be applied to white dwarfs and that matter in these stars is in a highly degenerate state.

The following discussion need be read only by those wishing an elementary explanation of what is meant by a degen-



The constellation of Canis Major, which contains the bright star Sirius, whose companion was the first white dwarf identified.

erate state of matter. Lennard-Jones[24] has explained in lucid and simple terms the main characteristics, differences, and applications of Maxwell - Boltzmann, Bose-Einstein, and Fermi-Dirac statistics.

When we have an enclosed assembly of atoms and molecules in gaseous equilibrium, not all the particles have the same velocity; there exists a distribution of velocities. We can take a three-dimensional space in which each of the axes represents the moment component of one particle in that direction, and subdivide that space into small cubic cells. The volume of each cell in this simple example is $\mathbf{h^3/v}$, where $\mathbf{h}$ is Planck's constant and $\mathbf{v}$ the volume per particle. If we suppose that each particle has its own individuality, so that it can be distinguished from the others, and that in each cell there can be any number of particles, we obtain the basis for the Maxwell-Boltzmann statistics, sometimes called "classical."

If, however, we suppose that the particles lose their individuality, so that it is not possible to distinguish one from the other in the same assembly, we can develop "modern" statistics, which may be separated in two groups. When each cell may contain any number of particles without individuality, we have Bose-Einstein statistics, which has proven to be the adequate one to treat a gas of photons. If, however, one particle at most can exist in each cell, we obtain Fermi-Dirac statistics; this principle has proven to be the appropriate one to treat a dense gas of electrons, as in the case of the free electrons of a metal.

For very high temperatures and low densities, the three statistics give approximately like results. But for not too high temperatures and high densities, Fermi-Dirac statistics give results completely different from others. In this case, even at absolute zero, there is going to be a rather high average velocity because in the central cell of zero velocity there is room only for one particle. On the other hand, in Maxwell-Boltzmann statistics, at zero absolute temperature all the particles are at rest.

When a gas obeys Fermi-Dirac statistics, it is said to be in a degenerate state. Therefore, by using this concept, it is possible to reduce the internal temperature of a star considerably without producing the collapse of the star; and by reducing the temperature, one reduces the radiation pressure, which in Eddington's models is more important than the gas pressure. Consequently, a denser state of matter is possible than with classical statistics. Fowler pictures the enormous energy of the white dwarfs as "cold energy." According to Fowler's model, a white dwarf would be something like a huge molecule in its ground state. (M. C. Johnson[25] gives a good elementary discussion of some theoretical aspects of white dwarf stars.)

In the white dwarfs, however, not only must the usual conditions of equilibrium of gravity versus radiation and gas pressure be considered, but account must be taken of the electrical attractions and repulsions among electrified particles when they are packed as closely as in the white dwarfs. If the positive and negative charges are evenly (statistically) distributed, they might be expected to cancel out, and Fowler considers that the positive and negative charges in any small volume inside a white dwarf neutralize each other. But each free electron has a very small mass in comparison with the ionized atoms (from which the electrons are derived) and, consequently, a relatively high velocity, particularly at high temperatures near the center of the star. Furthermore, the gravitational field produces a smaller effect on the electrons than on the nuclei, and we might expect very strong fluctuations in the distribution of the electric charges, even tending toward an average positive charge near the center of the star.

The resulting electrostatic effect would increase the repulsive forces between the positively charged nuclei (ions) near the center of the star and would prevent the matter there from attaining the required density. This thought also applies to Milne's[26] theory of the white dwarfs. These theories are based on large extrapolations of statistical theories, which ought first to be modified to apply them to the extreme conditions of matter in white dwarfs.[27]

Elimination of the high-velocity electrons, which cause the undesirable outward pressure, would simplify the explanation of the extremely high density in some white dwarfs. Kothari, in the paper mentioned, modifies the Fowler and Milne theories by assuming that the electrons with velocities higher than a certain value are absorbed by protons, transforming the latter into neutrons. In this way, he destroys the high-velocity electrons and thereby reduces the pressure of the electrons, succeeding in reaching higher densities than do the earlier theories. He can compute the existence of a white dwarf about equal in size to the earth, but his theory, unfortunately, sets an upper limit to the attainable densities which seems to be not high enough to explain some very dense stars. Luyten[27a] has discovered a double star whose components are white dwarfs with diameters probably smaller than that of the earth.

Here the reader should refer to Section 2 of the first installment in this series, where we point out that the mass of a neutron exceeds the sum of the masses of a proton and an electron by about 0.001 mass units or 0.932×10^6 electron volts. (See correction, *Sky and Telescope,* January, 1946, page 10.) Kothari considers that in a gas mixture of protons and electrons in a degenerate state (behaving according to Fermi-Dirac statistics instead of Maxwell-Boltzmann), the electrons with energies greater than 0.932×10^6 e. v. colliding with protons make them neutrons. Kothari's theory is based, therefore, on what appears to be a doubtful assumption. We have already presented reasons in favor of the alternative accepted by many physicists, that proton plus energy equals neutron plus positron. We shall not attempt to modify Kothari's theory with this alternative, however, for it would probably still not be possible to overcome the afore-mentioned difficulties.

It is interesting to note that the neutron appears in Kothari's theory as a by-product of the mechanism proposed for the white dwarfs, and not as an essential part to account for the high densities. We shall suppose the existence of neutron cores in white dwarfs, and suggest that by increasing the sizes of such cores to desired values it is possible to reach theoretically much higher densities than by Kothari's theory, and perhaps to explain the existence of stars as dense as Kuiper's white dwarf.

At the high densities at the centers of white dwarfs, the particles must be on the average between 10^{-10} and 10^{-11} centimeters apart. (The diameter of a normal atom is about 10^{-8} centimeters.) Two protons separated by a distance of 10^{-11} centimeters exert on each other a repulsive force of about 2,000 dynes, which corresponds to an acceleration of 10^{27} cm./sec.^{2} The gravitational acceleration at the surface of Kuiper's star is about 3,400,000 times that on the earth's surface, or about 3×10^9 cm./sec.^{2} Consequently, the acceleration produced by the electrostatic forces in two protons 10^{-11} centimeters apart is about 10^{18} greater than the gravitational acceleration at the surface of the densest star known. As we have mentioned, these repulsive forces are not considered in the foregoing theories, for they suppose an electrical space charge of zero in any small volume, but due to fluctuations in the distribution of particles this cannot be a valid assumption. If the matter which constitutes the center of a white dwarf were purely ionized particles, it would reach an explosive state before attaining the required density.

If the white dwarfs had central cores of neutrons, however, these difficulties would disappear. Because neutrons have no electrical charge, they can be packed together until they reach a density near to that of matter in the interiors of atomic nuclei, about 10^{14} grams per cubic centimeter.

In 1938, Landau[28] postulated the existence of a neutron core to develop a theory of the origin of stellar radiation. From the nuclei of atoms in the outer layers of a star, he obtains neutrons which subsequently gain energy by dropping to the neutron core. The difference in energy between the gain by gravitation as the neutron reaches the core and the energy necessary for the production of the neutron would be radiated. It is difficult, however, to picture how the neutron can gain the energy for its own production before it is formed; furthermore, in falling through

the star the neutrons would experience many collisions with atomic nuclei, and either be absorbed or produce various radioactive processes.

The application of Landau's theory to energy generation in any type of star appears very doubtful, and the radiation of ordinary stars is better explained by Bethe's carbon cycle, mentioned last month. Landau did, however, propose the neutron core, and even calculated its mass (as required for his process) as at least 10^{32} grams, which is 1/20 the sun's mass. Other writers, such as Baade and Zwicky,[29] Gamow,[30] Oppenheimer and Serber,[31] have also assumed the existence of stellar neutron cores, although for reasons and purposes different from ours, but their work is very useful for our theory.

A very detailed analysis of matter at high temperatures and pressures has been made by Hund.[32] He has assumed that nuclear reactions of four kinds may occur: 1. Atomic nuclei may form or be formed of neutrons and protons. 2. A neutron is composed of a proton and an electron. 3. Atomic nuclei are composed of protons and electrons. 4. Neutrons may be obtained by adding electrons to atomic nuclei. As has been mentioned, the second case might be replaced by supposing that a neutron plus a positron may form a proton. But it is still very difficult to draw definite conclusions regarding the behavior of matter in equilibrium at very high temperatures and pressures. Most probably, knowledge gained in the study of internuclear forces and the mechanism of nuclear chain reactions for improvement of the atomic bomb will make rapid advances in this field possible in the future.

A further complicating factor is the problem of the neutrino. This is a particle whose existence is assumed to explain the energy distribution corresponding to the emission of electrons in the radioactive process known as beta-decay. The neutrino is supposed to be the "thief" which escapes with the energy; it has no electrical charge and its mass is of the order of that of the electron. The neutrino is at present only a hypothesis which may prove to be unnecessary if beta-decay can be otherwise explained.

Meanwhile, however, if the existence of the neutrino is admitted, we cannot ignore it in dealing with the possible reactions taking place in the interiors of the stars.[33] The neutrino would have such extreme penetrating power, it could go across a mass of lead as thick as the distance from the sun to the nearest star. There might be some such reaction as the combining of a neutron and an electron-positron pair to form a proton, and an electron and a neutrino. The neutrino would be able to escape directly from the stellar interior and to carry away some energy which would not be converted into other forms.

Besides that, neutrinos would be produced, if we accept their existence, in all radioactive processes involving the emission of electrons or positrons, and consequently in Bethe's carbon cycle. The stars would appear to have "neutrino holes" from which energy would be lost. But if we can show, by combining observational data with the theory of the internal constitution of the stars, that they do not lose energy in this way, we shall have proved astrophysically the non-existence of the neutrino. It seems from present stellar models that the neutrino is not necessary.

Another difficulty which arises with matter at extreme conditions comes, we believe, from the assumption implicit in quantum mechanics, that the elementary particles have invariant properties. Professor Ellis from Cambridge, England, at a lecture at Princeton in 1939, indicated the convenience of assuming a structure for the electron which allows internal changes, thereby explaining certain experimental facts. Might not other fundamental particles also be similarly constructed? In the extreme conditions inside a white dwarf, they might reach different states of excitation.

If we assume an internal structure for the electron,[34] the need for postulating another particle, the mesotron, might be eliminated. This particle is of positive or negative charge and of a mass about 200 times the electron's. The mesotron was discovered in the study of cosmic rays, and it has been found to have a very short life, on the average about two millionths of a second. It is supposed that at the end of its life a mesotron disintegrates with the emission of a neutrino and then becomes an electron or a positron. If the electron has an internal structure, then these characteristics would indicate the mesotron to be an excited state of the electron. In the interiors of the densest stars, then, we ought to expect the formation of pairs of mesotrons as well as of pairs of electrons. As far as we know, the role of the mesotron in the interior of the stars has not yet been investigated. Other experimental facts, too, might be explained by an excited-electron hypothesis.

Returning to the assumption of a neutron core to explain the extremely high densities of the white dwarfs, a rough calculation can be made, but a choice must be taken between using Fermi-Dirac statistics and the laws of perfect gases. Classically considered, the ordinary gas law may be applied, for temperatures of the order of magnitude of 20 million degrees, to a density corresponding to about 10^{31} neutrons per cubic centimeter, that is, until an average distance between nearest-neighbor neutrons is of the order of or greater than 10^{-10} centimeters. On the other hand, Fermi-Dirac statistics implicitly assume a repulsive interaction among the particles of the gas, thereby producing a higher pressure. Such is obviously the case for electrons and other ions, but between neutrons at distances of about 10^{-13} centimeters (order of magnitude of nuclear diameters), we should expect attractive forces as strong as those acting between a pair of particles inside the nucleus (see Section 3). These conditions correspond to having 10^{39} neutrons per cubic centimeter.

For the case of a very high-density neutron gas, therefore, Fermi-Dirac statistics should be modified to take into account these attractive forces,[35] and we choose the perfect gas law in making our calculations as bringing about a better approximation than Fermi-Dirac statistics. In making this choice, we should note that the pressure of a dense gas of neutrons is independent of the temperature in Fermi-Dirac statistics, but it is proportional to the temperature in the classical gas law. We suppose, then, that the perfect gas law is valid for extremely high temperatures and pressures, and calculate the pressure corresponding to a temperature of 20 million degrees, with the number of neutrons of the order of 10^{39} neutrons per c. c.

(*Continued on page 22*)

BIBLIOGRAPHY

20. Arthur Stanley Eddington, *The Internal Constitution of the Stars*, Cambridge University Press, 1926.
21. D. S. Kothari, Neutrons, Degeneracy and White Dwarfs, *Proceedings* of the Royal Society, A, *162*, 521, 1937; *Science and Culture*, *4*, No. 5, 310, 1940.
22. G. P. Kuiper, The White Dwarf A.C. +70° 8247, the smallest star known, *Publications*, Astronomical Society of the Pacific, *47*, 307, 1935.
23. R. H. Fowler, *Statistical Mechanics*, Ch. XVI, Cambridge University Press, 2nd ed., 1936.
24. J. E. Lennard-Jones, Some Recent Developments of Statistical Mechanics, *Proceedings*, Physical Society of London, *40*, 320, 1928.
25. M. C. Johnson, *The Observatory*, March, 1938, p. 74.
26. E. A. Milne, *Monthly Notices*, Royal Astronomical Society, *92*, 611, 1932.
27. F. Cernuschi, Una generalizacion de le mecanica estadistica de Fermi-Dirac, *Revista de Matematicas y Fisica Teorica*, Universidad de Tucuman, Argentina, *1*, 267, 1940.

27a. W. J. Luyten, The White Dwarfs, *Science*, *101*, No. 2613, 79, 1945.

28. L. Landau, Origin of Stellar Energy, *Nature*, *141*, 333, 1938.
29. W. Baade and F. Zwicky, *Proceedings*, National Academy of Sciences, *20*, 259, 1934; F. Zwicky, *Astrophysical Journal*, *88*, 522, 1938.
30. G. Gamow, *Atomic Nuclei and Nuclear Transformations*, 234, Oxford Press, 2nd ed., 1936.
31. J. R. Oppenheimer and Robert Serber, On the Stability of Stellar Neutron Cores, *Physical Review*, *54*, 540, 1938.
32. F. Hund, *Ergebnisse der Exakten Naturwissenschaft*, *15*, 189, 1936.
33. F. Cernuschi, *Physical Review*, *56*, 450, 1939.
34. F. Cernuschi, *Comptes Rendus*, *203*, 777, 1936.
35. F. Cernuschi, *Revista de Matematicas y Fisica Teorica*, Universidad de Tucuman, *1*, 255, 1940.

Amateur Astronomers

THIS MONTH'S MEETINGS

Boston: Herbert B. Nichols, of the *Christian Science Monitor* staff, will speak at the Bond Astronomical Club meeting on February 7th, 8:15 p.m., at the Harvard College Observatory, Cambridge. His topic is "A Science Editor Looks at Wartime China."

Chicago: The Burnham Astronomical Society will meet for a Telescope Night on February 12th at 8:00 p.m., at the Chicago Academy of Sciences Auditorium. The program includes a general discussion of the February evening sky, a question box, and a series of talks on Making Your Own Telescope. A telescope exhibition concludes the meeting.

Cleveland: Dr. S. W. McCuskey, of the Warner and Swasey Observatory, will speak on "The Rotation of the Galaxy" at the February 8th meeting of the Cleveland Astronomical Society. The meeting is at 8:00 p.m., at the Warner and Swasey Observatory, East Cleveland.

Detroit: Dr. W. L. Brosius will give an address on "Glaciation and the Michigan Landscape," with original slides, at the Detroit Astronomical Society meeting on Sunday, February 10th, 3:00 p.m., at Wayne University.

Geneva, Ill.: A symposium on modern astronomy, including talks on radiation, the spectroscope in modern astronomy, and atomic energy, will be given on February 19th at the Fox Valley Astronomical Society meeting, 8:00 p.m., at the Geneva City Hall.

Indianapolis: "Sky Information Please," with the Board of Officers conducting, will be presented at the February meeting of the Indiana Astronomical Society. The group meets at Odeon Hall, 2:15, on Sunday, February 3rd.

Madison: "Nebulae in the Milky Way" is the subject of the talk by Dr. C. M. Huffer, of Washburn Observatory, to the Madison Astronomical Society, which will meet at the observatory on February 13th.

New York: At the February 6th meeting of the Amateur Astronomers Association, Everett C. Yowell, of Columbia University Observatory, will speak on "Distant Neighbors, the Nebulae." The lecture is at 8 o'clock in the Roosevelt Memorial building of the American Museum of Natural History.

The Junior Astronomy Club meets, also at the museum, on February 15th, at 8:00 p.m. Willy Ley, science editor of *PM*, will speak on "Rockets."

Pittsburgh: On February 8th, M. M. Eakins, research engineer at the Pittsburgh Plate Glass Co., will discuss "The Commercial Manufacture of Optical Glass." This meeting of the Amateur Astronomers Association of Pittsburgh will be at the Buhl Planetarium at 8 o'clock.

Worcester: The Aldrich Astronomy Club, meeting on February 12th at the Worcester Natural History Society, will hear a talk on "The Sun," to be given by Dr. Donald H. Menzel, of Harvard Observatory.

Washington Amateurs Return to Naval Observatory

Two small buildings, Nos. 14 and 15, on the grounds of the U. S. Naval Observatory, are open for use by the National Capital Amateur Astronomers Association. The society's 5-inch telescope has been set up in one of the buildings and plans are under way to build a permanent mounting. The other building will be used for members' portable instruments.

"Backyard Astronomer"

Clarence L. Friend, of Escondido, Cal., co-discoverer with L. C. Peltier of the recent comet (see the Observer's Page last month) was pictured and written up on the Science page of a recent issue of *Time* magazine. Apparently, a *Time* editor, supposing that Mr. Friend would not quickly figure the *wrong* ascension and declination of the object, thought that "ascension and declination" was sufficient description of the comet's position.

Yakima Amateurs Expand Activities

After carrying on a modified program during the war years, the Yakima Amateur Astronomers are returning to a full program under the leadership of Edward J. Newman, president. He has been absent for three years, during which Orris Thompson has done good work in keeping interest alive.

The Observer, monthly bulletin of the Yakima group, is also resuming publication after a lapse of two years. The January, 1946, issue appears in four-page printed form; it is No. 1 of Vol. 7.

Memphis Telescope Makers

A letter from R. E. Wendt, Jr., acting for the membership of the Amateur Telescope Makers of Memphis, Tenn., reports:

"The death of our president, James Woody, in his 19th year, has made necessary suspension of all further activity until the remaining members return from service in the armed forces."

Here and There with Amateurs

The list of amateur societies throughout the country, which appears on page 22 of this issue, is up-to-date according to all information received by the editors at the time of going to press. Will officers of amateur societies check the data as it appears, and forward any revisions which are necessary? ED.

ASTRONOMY AT HOWARD UNIVERSITY

The first observatory at an institution for negroes in this country is planned to be built by Howard University at Washington, D. C. A 30-inch reflecting telescope will be constructed and housed, as part of a building program for early postwar years. Accessories will include a spectrograph and photometer. Meanwhile, a 12½-inch, privately owned reflector will be mounted in a temporary observatory atop the engineering building of the university.

Dr. W. A. Calder, on wartime leave from Carleton College, Northfield, Minn., is in charge of the program. The university staff is offering courses in elementary astronomy, and later advanced classes will be added. Dr. Calder plans to have public observations and an amateurs' group if interest warrants. He will bring his grinding machine from the Middle West and make it available to prospective A.T.M.'s, having been an amateur telescope maker himself.

MABEL STERNS

LARGE PRISM

The New York *Herald Tribune* recently reported that the Bausch and Lomb Optical Company at Rochester has produced the largest piece of optical glass ever cast, weighing 379 pounds. The casting required two months, and an equal period is needed for the annealing.

The glass will be ground and polished by the Perkin-Elmer Corporation, Glenbrook, Conn., to form an objective prism for the Schmidt camera at the Mexican National Observatory, Tonanzintla, Puebla.

Celestial Gleanings

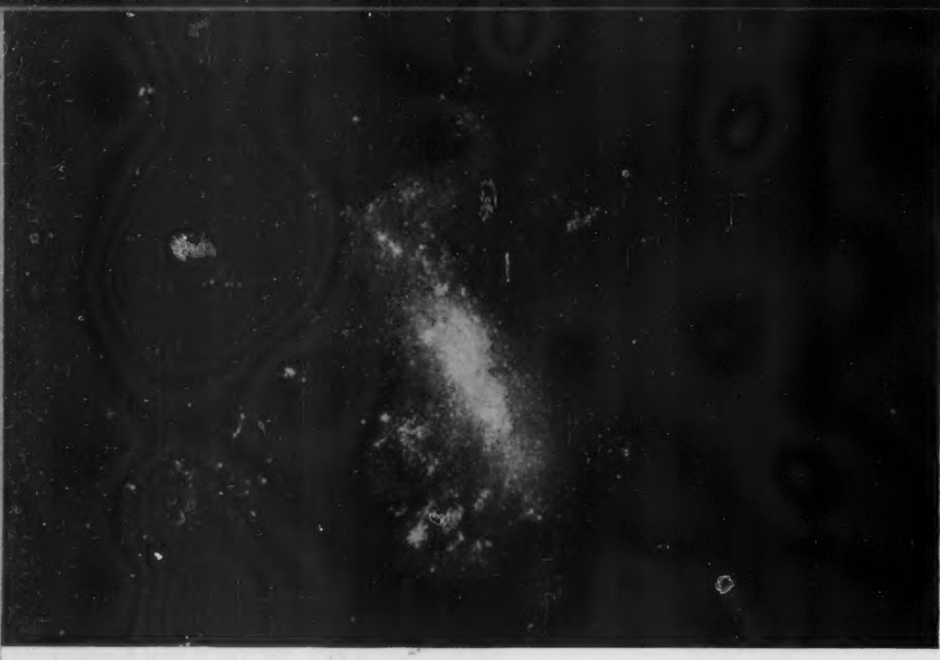
From Jupiter, the earth would never appear to be farther than 12 degrees from the sun.

The largest constellation in area is Hydra, followed by Virgo and Ursa Major.

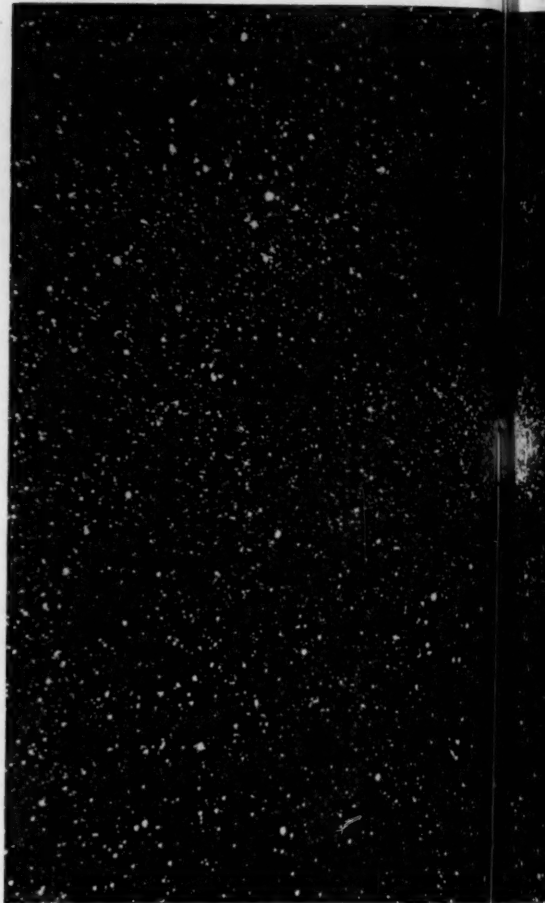
The smallest constellation in area is Crux, and next come Equuleus and Sagitta.

Every calendar year there must be two eclipses of the sun, and there may be up to seven of the sun and moon combined.

EDWARD ORAVEC



OUTPO



IN a certain sense it may be said that the great population which inhabits the heavens is of two worlds. One of these is revealed to the unaided eye—the only world that was surely known to exist before Galileo turned his telescope on the stars early in the 17th century. The other is that much vaster realm the astronomer explores with his instruments. And fortunately, it has been found that the former, foreground world is a fair sample of the latter, in that it contains representative types of many objects existing in the more remote region.

It is with certain reservations that we refer here to the "outposts of the heavens." By this phrase we mean the outlying members of the universe thus far explored. For the region observable to the unaided eye, these outposts are probably as well recognized today as they will be in the future. But for the telescopic world it is a different story. There the galaxies which represent the remote boundaries of space explored today may soon join the inner hosts, as greater telescopes are turned on the sky and new techniques are applied.

Before discussing these farther outposts let us consider, in broad outline, the foreground of the sky picture. With a very few notable exceptions, this is composed of objects that belong to the Milky Way galaxy. Our sun, with its family of planets, is situated about 30,000 light-years from the center of this galaxy, which center is located in the Milky Way in the constellation of Sagittarius. In addition to the sun, our galaxy contains many billions of individual stars, about 6,000 of which are ordinarily visible to the naked eye. These, irregularly scattered, make up definite patterns that we call the constellations. The stars appear to differ in brilliance and color. Some are red like Antares; some, such as Sirius, are blue-white; and others, like Capella, are yellow. The astronomer has discovered that they range in size from stars tremendously larger than the sun to others that are comparable to some of the planets. They also differ greatly in temperature, mass, and density.

The telescope reveals that many of these stars are double; some are triple systems, and others are of more complex arrangement. There are many open or galactic clusters of stars, such as the Pleiades and the Hyades, the members of which are traveling together through space. Also, about 100 globular clusters have been discovered, each containing many thousands of stars. Although most of these globulars are visible only with a telescope, there are a few exceptions. One, known as M13, in the constellation of Hercules, is plainly visible to naked-eye observers in the Northern Hemisphere. This interesting object is at a distance of about 31,000 light-years; some of its individual stars are readily observable with moderate-sized telescopes.

In addition to the varied groupings of stars, our galaxy also contains great accumulations of hazy, nebulous material, some gathered to form various diffuse nebulae, of which the Great Nebula in Orion is one example. Then there are regions of dark obscuring matter that actually blot out the stars beyond, such as the famous Horsehead nebula and the dark lanes that extend throughout much of the Milky Way and are so conspicuous in the constellation of Cygnus. While these bright and dark nebulae are interesting objects to observe and study, there is a tremendous amount of this dust-like material scattered through the galaxy, especially in the plane of the Milky Way. This nebulosity is difficult for the astronomer to penetrate, and, consequently, his estimates of the distances to remote objects must be carefully corrected.

Among the many interesting stars that belong to the Milky Way system, one of the most important types is the Cepheid variable, named for Delta Cephei, the first star of this kind studied. Cepheids are pulsating stars which increase and diminish in magnitude with definite periods of such regularity that they might be suitably employed as timepieces. Over three decades ago, Henrietta Leavitt, of Harvard College Observatory, discovered a remarkable relation between the intrinsic brightness of such stars and the time required for them to go through their cycle of magnitude changes. The fainter stars have relatively short periods, while the brighter ones have longer periods. Since stars of this type are very widely distributed throughout the Milky Way (Polaris is a Cepheid variable with a period of nearly four days), and also in the galaxies beyond our system, they have provided us with a most valuable method of calculating distances far beyond the greatest depths that can be accurately measured by the trigonometric parallax method. Careful research has determined how to tell the actual or intrinsic brilliance of a Cepheid variable from its period. This, compared with the apparent brightness of the star, gives its distance — with certain corrections for the absorption caused by the presence of the obscuring haze that may intervene. Since the globular clusters contain many Cepheids, their distances have been calculated in this fashion.

POSTS OF THE HEAVENS

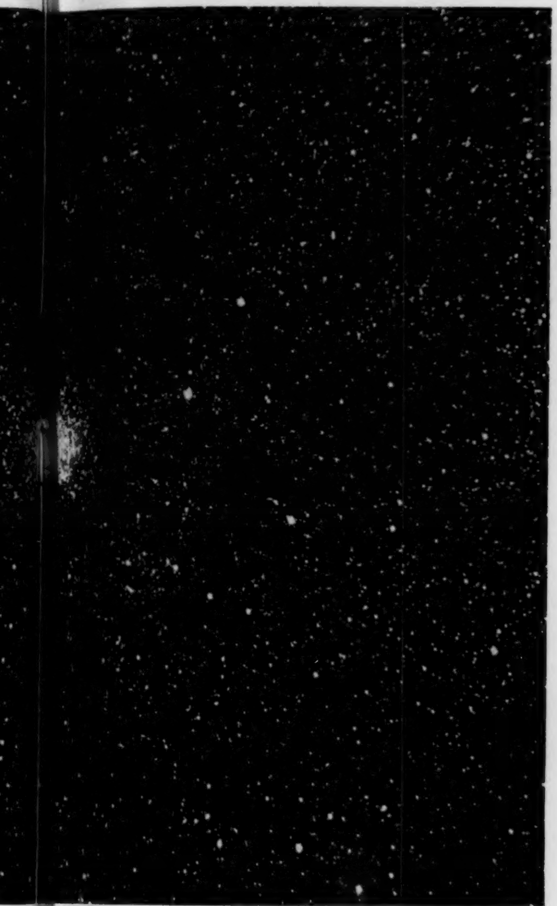
By Robert R. Coles, *Hayden Planetarium*

The basic structure, containing probably 99 per cent or more of the matter in this home galaxy, is more-or-less lens-shaped, like a pocket watch. As we see this system, its principal plane is represented by the path of the Milky Way. And recent investigations indicate that there is a haze of outlying stars which extends for some distance beyond this inner structure, apparently thinning out into the region of intergalactic space. The diameter of the main structure has been estimated as about 100,000 light-years and its thickness as about 10,000 light-years. The star haze beyond extends perhaps 30,000 to 50,000 light-years; its stars are the outposts of the Milky Way galaxy.

Although it is exceedingly brief, we shall have to let the foregoing description of our local system suffice, and turn our attention now to those galaxies that lie beyond. For the naked-eye observer, these exterior systems are few in number, and here we shall specifically mention only three.

The nearest are the famous Magellanic Clouds, so conspicuous for observers in the Southern Hemisphere. The Small Cloud is at a distance of 84,000 light-years, and the Large at 75,000 light-years. Because they lack a regular shape or symmetrical appearance, they are described as irregular galaxies. These relatively near neighbors to the Milky Way are a veritable mine of interesting and extremely valuable observational material. They possess quantities of Cepheid variable stars. Indeed, it was in connection with the Cepheids in these systems that the value of these stars as celestial yardsticks was first discovered. The Magellanic Clouds also contain many types of star clusters, gaseous nebulae, supergiant stars, and other objects similar in nature to those known to exist in our own galaxy. In the Large Cloud there is 30 Doradus, a tremendous gaseous nebula, also known as the Great Loop nebula; it can be observed with the unaided eye despite its great distance. The famous Orion nebula is a mere dwarf compared with 30 Doradus; Shapley tells us that if this nebula were in Orion it would fill the whole constellation. Famous among the many interesting stars discovered in the Clouds is S Doradus, also in the Large Cloud. This is a supergiant variable whose average luminosity is said to be about 500,000 times as great as that of our sun. Re-

(*Continued on page* 15)



UPPER LEFT: The nearest of the exterior systems, the Large Magellanic Cloud, as photographed from Harvard's station in the Southern Hemisphere. It is situated in the constellations of Dorado and Mensa, not far from the south pole of the heavens.

CENTER: Although this globular cluster is actually located in a heavily obscured region of the Milky Way, this picture shows many stars in its vicinity because the photograph is taken with red-sensitive emulsion. In this way, the obscuring effect of interstellar dust is partially overcome.

LOWER RIGHT: A distant group of galaxies, known as Stephan's quintet. It comprises four spirals and one spheroidal system. One of the galaxies is intermingled with another, a feature which may have an important bearing on the problem of galactic evolution.

BOOKS AND THE SKY

ATOM SMASHERS

Raymond F. Yates, Didier Publishing Company, New York, 1945. 182 pages. $2.00.

ATOMIC ARTILLERY AND THE ATOMIC BOMB

J. K. Robertson, D. Van Nostrand Company, New York, 1945. 173 pages and plates. $2.50.

IF JOURNALISTS and physicists would collaborate in popular scientific writing, they could produce books at once better written and technically more accurate than the literature now appearing on such subjects as atomic energy. The journalist knows how to present his material in ways which keep the average reader interested, and the physicist can insure the correct presentation of the facts.

These two volumes are good examples of a lack of this sort of co-operation. Mr. Yates' book is written in an interesting, informal style which provides very pleasant reading, but he includes half a dozen or so rather serious errors of fact. Professor Robertson's book, on the other hand, appears accurate in every detail, but in ease of presentation it cannot compare with Mr. Yates' treatment.

As the titles would suggest, both books seem to have been written before the current wave of popularity for nuclear physics. Each author has added at the end a chapter or two on the atomic bomb. Both stick to the facts and do not try to predict the trend of future events.

The errors in fact from which *Atom Smashers* suffers include the attraction of electron beams toward a magnet, the disproved theory that the nucleus consists of electrons and protons, and the statement that the deuteron is an isotope of water. On the whole, however, the historical development of the cyclotron and the Van de Graaf generator is well presented. The only part in which Mr. Yates tends to bore his reader is his description of "what it is like to 'sit in the driver's seat' of a modern atom smasher." The detailing of "operation 1" through "operation 10" on how one might turn on a cyclotron has very little to do with the textual material.

Atomic Artillery and the Atomic Bomb is essentially a description of the artillery. It is a carefully written book on the projectiles of atomic physics and the important phenomena which occur when these projectiles are shot at a nucleus. It is easy to detect the hand of a professional physicist, and the lay reader may not find the book easy reading in some places. It is well worth his careful attention, however, for the material is authoritatively discussed and represents a good coverage of the background of nuclear physics. Two chapters, "Nuclear Fission and Chain Reactions" and "The Bomb," are taken directly, without embellishment, from the Smyth report. Professor Robertson (head of the department of physics, Queen's University, Kingston, Ont.) points out quite correctly that Canada contributed to the atomic bomb project not only much of the raw material, but co-operated by establishing the most extensive research program ever carried out in the Dominion.

These two books cover essentially the same material, the projectiles of modern physics. *Atom Smashers* is more colorfully written, and *Atomic Artillery* is by far the more scholarly.

SANBORN C. BROWN
Massachusetts Institute of Technology

THE MILKY WAY

Bart J. Bok and *Priscilla F. Bok*, The Blakiston Company, Philadelphia, 1945. Second edition. 224 pages. $2.50.

THE POPULARITY of the several books of the Harvard series can best be gauged by the fact that most of them have been reprinted and that now one of the first to appear is in a second edition. There are 20 new pages, in an added chapter, "Postscript." Actually, the book is the same as the first edition, with this added chapter. It would have been better if the material of "Postscript" had been integrated with the pertinent material sprinkled throughout the original 11 chapters, but this would have made it necessary to reset about half of every chapter. It might have been possible to help the reader by adding Postscript references to the original material.

There is a new table of contents in which brief descriptive phrases tell what is in each chapter. Only a few changes have been noticed in the body of the work. A new clarified figure of Barnard's star shows its motion in only 11 months. In Chapter 3, the list of stars nearer than 16 light-years (which all dictionaries hyphenate, by the way) has been revised by the addition of recent data and a new spectrum-absolute-magnitude diagram has been drawn. A new picture of the Orion region is used on page 119.

ROY K. MARSHALL
Fels Planetarium

NEW BOOKS RECEIVED

Atomic Artillery and the Atomic Bomb, *J. K. Robertson*, 1945, *Van Nostrand*. 173 pages and plates. $2.50.

A revision of the author's *Atomic Artillery*, published in 1937, brings up-to-date his popular presentation of the subject of atomic physics.

Science of the Seven Seas, *Henry Stommel*, 1945, *Cornell Maritime Press*. 208 pages. $2.50.

A handbook for the past or future traveler, in layman's language, discussing the various sciences above, on, in, and under the sea.

The River Mathematics, *Alfred Hooper*, 1945, *Holt*. 401 pages. $3.75.

The author traces the history of the development of mathematics, and leads the reader, with copious drawings and equations, through some of the simpler arithmetic, and on to discussion of geometry, trigonometry, and calculus.

OUTPOSTS OF THE HEAVENS

(*Continued from page* 13)

cent investigations seem to reveal that this star is actually a double — two stars that revolve about a common center of gravity in about 40 years.

The smaller of the Magellanic Clouds is less than four degrees in diameter and the larger is less than eight degrees. They are considered as satellites of our own galaxy, being near enough to be appreciably within its gravitational influence.

While observers in the United States are not favored by having these interesting galaxies in view, we can, however, see an object that for size and distance surpasses the Clouds of Magellan many times. This is the Great Nebula in Andromeda, a system of stars at a distance of approximately 750,000 light-years. Although merely a hazy patch of light to the unaided eye, this huge system appears magnificent on a photographic plate. As galaxies go it is a giant, some 35,000 light-years in length and 8,700 in width. Its elliptical shape results from our point of view; the Andromeda galaxy is a flattened spiral, which would be seen circular if viewed full-face. It contains many Cepheids, from which its distance has been determined; there are supernovae, open clusters, globular clusters, gaseous nebulae, and, in fact, representatives of most of the types of objects we find in our own galaxy.

Not far from the Great Nebula in Andromeda are two lesser members of the extragalactic world, known as M32 and NGC 205, neither of them visible to the unaided eye. The former is a spheroidal galaxy in which individual stars have been photographed; the latter is a dwarf galaxy.

Throughout intergalactic space, millions of galaxies have been observed — the outposts of the universe as far as modern photographic telescopes will reach today. The distance to the farthest known galaxies, some 500 million light-years according to Hubble, represents the extreme depths to which the 100-inch telescope at Mount Wilson has penetrated. Shapley states that it is within the realm of probability that the greatest telescope now available — the 200-inch — using the fastest photographic plates, may record the images of galaxies at the stupendous distance of 1,600,000,000 light-years!

Naturally, such figures are staggering to the imagination. Distances of 9,500,000,000,000,000,000,000 miles are considerably beyond the limit of our daily experience. To say that they are out of this world is hardly an exaggeration.

And when we consider the story of these remote galaxies as revealed by the red shift in their spectra, which tells us — if we are to accept the standard interpretation — that the farther galaxies are receding at continuously accelerated speeds, so that the radius of the observable universe doubles itself in 1,300,000,000 years, there are many who do begin to question the interpretations.

We wonder what awaits the great 200-inch giant now being completed on Mount Palomar. But we must wait patiently and, in the meantime, astronomers will continue to explore these distant outposts. They will revise their estimates as new evidence is discovered, and gradually they will approach that total perspective which is their goal.

Planetarium Notes

ADLER PLANETARIUM

900 E. Achsah Bond Drive, Chicago 5, Ill., Wabash 1428

SCHEDULE: Tuesdays through Saturdays, 11 a.m. and 3 p.m.; Sundays, 2:30 and 3:30 p.m.; building closed Mondays.

STAFF: *Director*, F. Wagner Schlesinger. *Other lecturer:* Harry S. Everett.

February: EVOLUTION OF THE CALENDAR. In tracing the history of the calendar, emphasis is laid upon the relation of its principal periods to the various astronomical motions from which they are derived.

BUHL PLANETARIUM

Federal and West Ohio Sts., Pittsburgh 12, Pa., Fairfax 4300

SCHEDULE: Mondays through Saturdays, 3 and 8:30 p.m.; Sundays and holidays, 3, 4, and 8:30 p.m.

STAFF: *Director*, Arthur L. Draper. *Other lecturers:* Edwin Ebbighausen, Fitz-Hugh Marshall, Jr., Nicholas E. Wagman.

February 1-24: MARS AND SATURN—MYSTERY WORLDS. Red Mars and yellow Saturn are first seen against the winter stars, then as they appear through telescopes. What life might be on Mars? What may have been the origin of Saturn's rings?

Beginning Feb. 25: GIANTS IN THE SKY. The legendary heroes of the heavens, and the tales told about them.

FELS PLANETARIUM

20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Rittenhouse 3050

SCHEDULE: 3 and 8:30 p.m. daily; also 4 p.m. on Saturdays, Sundays, and holidays. 11 a.m. Saturdays, Children's Hour (adults admitted).

STAFF: *Director*, Roy K. Marshall. *Other lecturers:* I. M. Levitt, William L. Fisher, Armand N. Spitz, Robert W. Neathery.

February: STARS AND ATOMS. The story of atomic energy from the sun and other stars, and of man's knowledge and use of atomic energy today and in the future.

GRIFFITH PLANETARIUM

P. O. Box 9866, Los Feliz Station, Los Angeles 27, Cal., Olympia 1191

SCHEDULE: Friday and Saturday, 3 and 8:30 p.m.; Sunday at 3, 4:15, and 8:30 p.m.

STAFF: *Director*, Dinsmore Alter (on military leave). *Acting Director*, C. H. Cleminshaw. *Other lecturer:* George W. Bunton.

February: THE WINTER STARS. The principal stars and constellations of the winter sky are pointed out. Outlines of mythological figures are reproduced among the stars.

March: THE NORTHERN LIGHTS.

HAYDEN PLANETARIUM

81st St. and Central Park West, New York 24, N. Y., Endicott 2-8500

SCHEDULE: Mondays through Fridays, 2, 3:30, and 8:30 p.m.; Saturdays, 11 a.m., 2, 3, 4, 5, and 8:30 p.m.; Sundays and holidays, 2, 3, 4, 5, and 8:30 p.m.

STAFF: *Honorary Curator*, Clyde Fisher. *Chairman and Curator*, Gordon A. Atwater. *Other lecturers:* Marian Lockwood, Robert R. Coles, Catharine E. Barry, Shirley I. Gale.

February: OUTPOSTS OF THE HEAVENS. We explore the visible universe, stretching 500 million light-years in all directions, with its millions of galaxies. Are these parts of an infinite universe? Is space curved or straight?

March: EYES OF THE ASTRONOMER.

OBSERVER'S PAGE

Greenwich civil time is used unless otherwise noted.

Reports on the Lunar Eclipse

NEITHER very good weather nor very bad weather was the overall order for the lunar eclipse in December. Widespread reports from amateurs have been received, and many of these, in part or complete, follow:

California. Lewis Lindsay, San Francisco amateur and author of the November article on "Color Sequences in Lunar Eclipses," writes that the event was almost a complete blank. "At a point about 18 miles south of San Francisco, along the bay shore, the moon was invisible until 6:30, when at 30 degrees above the horizon it appeared intermittently as a vague light spot in the clouds. The lower limb of the emerging moon was plainly visible, but clouds blotted out all colors.

"After 7:30, with half the moon in the clear, the remainder of the eclipse appeared normally in a clear, night sky with the earth's shadow blending into the surrounding darkness."

Canada. Calgary and Wolseley had good weather, but a friend writes that it was "rather cloudy" at Bredenbury!

Cuba. Daniel Parets sent a Schmidt camera (6-inch f/1) photograph by Dr. Miguel Mery; 1½ minutes' exposure during totality gives a very bright moon!

District of Columbia. Washington amateurs say that the snow, though pretty, could not have picked a more inopportune night for blotting out the moon.

Florida. "Eclipse visible 2144 to 2244 EST," writes Wallace W. Fuller from Miami.

Jamaica, B.W.I. Lt. A. M. Mackintosh writes from Kingston: "We were favored with an absolutely clear sky. Unfortunately, my 10-inch reflector had developed a defect in the polar axis two nights before, but I watched with a 2-inch refractor and 10x40 binoculars. Probably they were much more satisfactory, as the reflector has not got a large enough field to get the full effect.

"Shortly before second contact, I noticed a distinctly blue tinge to the shadow, probably enhanced by the rosy color of the deeper shadow; I also noticed this after third contact. The moon in full eclipse was a magnificent sight, with the color varying from deep rose on the dark side to a lemon color on the side toward the light.

"The sky generally was glorious. Sirius was high and Canopus low on the southern horizon. In the northern sky, Saturn and Mars added to the constellation of Gemini.

"By the way, the diagram in the December **Sky and Telescope** was a bit mixed, wasn't it? Should have been 'umbra of the **earth's** shadow.'" **Correct.** The diagram was wrong. ED.

Maryland. Feeling the effect of Washington's bad weather, or vice versa, Dr. James C. Bartlett, of Baltimore, says: "My report is brief. We enjoyed a fine display of drifting cirrostratus accompanied by fractocumuli, and the beginning of an eight-inch snowfall — but no eclipse."

Massachusetts. The New England region seems to have been especially favored with practically clear skies throughout the eclipse. At Arlington, the editors watched a rising moon clear a low bank of cirrus, later to form a halo. At the moment of the beginning of totality, through a 3-inch refractor, the spectrum of the earth's atmosphere was strikingly visible on the moon. The colors ranged from a bright blue-white, through olive green and yellow to dusty orange and red. At the end of totality the colors were not nearly so pronounced.

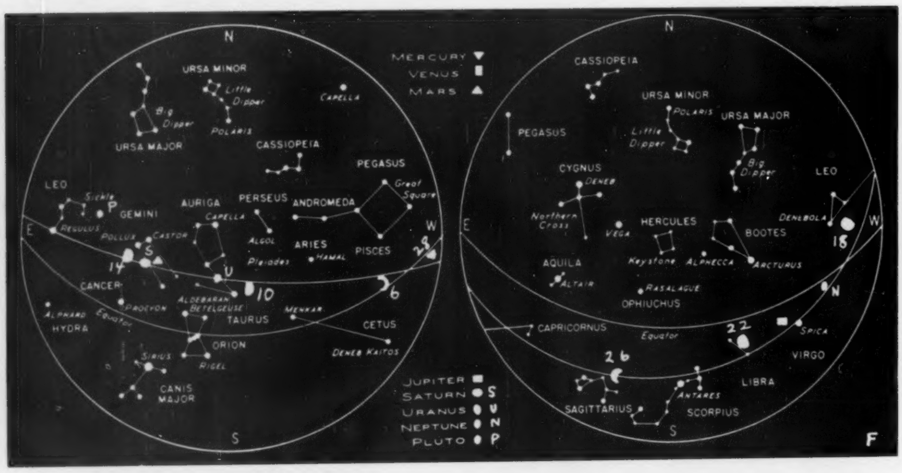
Minnesota. Eugene Young, of Paynesville, reports that he observed with LeRoy Laing for about three hours in 20 degrees below zero. "Seeing was good, as was also our luck, for clouds began setting in shortly after we stopped observing."

New Jersey. Although "practically clouded out," William and George Schuster got a few pictures at Irvington.

New York. Amateurs in the metropolitan area were generally hampered by partial or complete cloudiness, although some observations could be made. Peter Leavens, at Sayville, L. I., obtained an excellent post-totality photograph.

Rochester had a good view of the eclipse. About 20 members of the Rochester Academy of Science astronomy sec-

THE MOON AND PLANETS IN THE EVENING AND MORNING SKIES



In mid-northern latitudes, the sky appears as at the right at 7:30 a.m. local time on the 7th of the month, and at 6:30 a.m. on the 23rd. At the left is the sky for 7:30 p.m. on the 7th and 6:30 p.m. on the 23rd. The moon is shown for certain dates by symbols which give roughly its phase. Each planet has a special symbol, and is located for the middle of the month, unless otherwise marked. The sun is not shown, although at times it may be above the indicated horizon. Only the brightest stars are included, and the more conspicuous constellations.

Mercury crosses into the evening sky on February 11th, superior conjunction taking place then. The planet attains its greatest brightness at this time, but not until it nears greatest western elongation in March will Mercury be placed for favorable observation.

Venus also moves into the evening sky this month, on the 1st, but will set too soon after the sun for normal observation.

Mars, having passed opposition last month, continues retrograde or westward motion until February 22nd, when it reaches a stationary point in central Gemini. The ruddy planet forms a rectangle with Saturn to the east and Castor and Pollux above, during the latter half of the month. The moon passes between the two planets on the 13th at 5 hours, GCT. Mars decreases in brightness during February from —0.8 to —0.1, and its apparent diameter on the 1st is only 13 seconds of arc.

Asteroids. None of the minor planets is well placed for low-power observation until later in the year.

Jupiter, the only morning star except Neptune, hovers in eastern Virgo, about five degrees east of Spica. For latitudes near 40°, it rises about five hours after sunset on the 15th; it presents a 37-second disk, a fine telescopic object.

Saturn appears as an object of magnitude 0.00, crossing the meridian at about 9:30 p.m., local time. Saturn is very close to the point in the sky where Pluto was discovered just 16 years ago, and not far from Delta Geminorum.

Uranus remains practically motionless all month; it can be easily picked up in opera glasses near Tau Tauri, as it is of the 6th magnitude. Its position is $4^h\ 48^m$, —22° 27′ (1946).

Neptune is in Virgo, between Eta and Gamma; of the 8th magnitude.

Pluto is in Cancer, passing opposition early in the month.

EDWARD ORAVEC

MINIMA OF ALGOL

Feb. 1, 1:12; 3, 22:01; 6, 18:50; 9, 15:39; 12, 12:28; 15, 9:17; 18, 6:06; 21, 2:55; 23, 23:44; 26, 20:33; Mar. 1, 17:22.

PHASES OF THE MOON

New moon	February 2, 4:43
First quarter	February 9, 4:28
Full moon	February 16, 4:28
Last quarter	February 24, 2:36

tion observed, with four telescopes and a movie camera. Paul Stevens reports very cold weather, but no wind. He writes: "There was a 22-degree halo conspicuous during both the initial and final partial phases. During totality, the halo was of course invisible, and as the moon emerged from the umbra, the circle of light gradually became bright as do lights in a theater at the end of an act. Castor and Pollux, Saturn, Aldebaran, and Orion's belt were near the ring itself, and the inner zones finally became tinged with red while the outer zones were greenish yellow. The halo emphasized the moon's central position among the brilliant stars of winter.

"It was my hope to observe changes in several lunar topographical features which had shown visible changes during previous eclipses, but I soon found out I needed much higher magnifying power than the 20x I was using. I had plotted the positions of all stars of the 7th magnitude or brighter in the vicinity of the moon and found none was to be occulted. In a 50x telescope were seen some stars which were doubtless occulted at some time during the eclipse; they must have been of 8th or 9th magnitude."

Oklahoma. From Shawnee, James Williams reported that it was cloudy only until shortly after first contact, and clear from then on. He used a 6-inch telescope, and made records of contact times as he observed them. He also noted times that several craters were eclipsed, and reports that during totality Tycho was just a white spot, irregular in shape, and Copernicus was invisible.

Oregon. A complete account and series photograph came from Carl P. Richards, of Salem, where the one clear evening in months occurred.

Pennsylvania. At Sinking Spring, Charles M. Paulus used 18x50 binoculars but says that the seeing was best with a 4x Galilean field glass. The sky cleared just in time for totality.

Washington. Seattle, which was clouded out at the August, 1942, lunar eclipse, was compensated this year. J. Franklin Peters reports: "At sunset the moon rose with a red-orange hue which turned quickly to lemon yellow. Until about 5:30, the moon was seen through stratified wisps of cirrus which really added to its beauty; after 5:30, it was entirely in the clear.

"Colors were especially nice viewed through our 6-inch reflectors, and I noted the following color changes. At 5:42, just after the total phase had begun, a bright slate blue on the side where the sunlight had just vanished, and a dusky rose on the opposite side. This color scheme prevailed through totality with varying intensities as the light shifted. At 7:15, the brightest portion of the shadow was peach-rose, and at 7:37, yellow-rose to russet. At 8:45, a grayed yellow-orange. This last color could be seen only by shifting the telescope so that only the shadow was in the field, thereby shutting out the sunlit portion.

"Since September, Seattle has had but one week of fair weather. We were indeed fortunate to have the eclipse featured during that week. The temperature was just under freezing — perhaps about 27 above."

OCCULTATION PREDICTIONS FOR FEBRUARY

7-8 **64 Ceti** 5.7, 2:08.5 +8-19.1, 6, +49° —30° Im: **A** 0:19.2 —0.7 +2.2 15°; **B** 0:27.9 ... ... 355°; **C** 0:08.3 —1.0 +1.9 25°; **D** 0:19.5 ... ... 358°; **E** 0:02.7 ... ... 354°.

10-11 **Iota Tauri** 4.7, 4:59.9 +21-30.9, 9, +45° —21° Im: **A** 1:13.1 —1.3 +4.5 16°; **C** 0:54.1 —1.5 +3.0 31°; **E** 0:48.0 ... ... 352°; **F** 0:03.3 —0.8 +2.8 34°.

10-11 **330 B Tauri** 6.3, 5:01.1 +21-12.2, 9, +70° —1° Im: **A** 1:29.1 —2.0 —1.2 106°; **B** 1:24.3 —1.8 —0.6 94°; **C** 1:24.8 —2.4 —2.0 119°; **D** 1:14.5 —2.0 —0.5 98°; **E** 0:51.2 —2.2 —0.1 100°; **F** 0:42.0 —3.9 —3.0 132°; **H** 0:02.8 —0.8 +1.6 70°.

10-11 **105 Tauri** 6.0, 5:04.7 +21-38.1, 9, +51° —15° Im: **A** 3:37.3 —1.5 +0.8 44°; **B** 3:39.4 —1.5 +1.7 31°; **C** 3:28.5 —1.6 +0.3 60°; **D** 3:27.7 —1.6 +1.1 42°; **E** 3:04.9 —1.8 +0.9 58°; **F** 2:46.8 —2.5 —0.2 91°; **H** 2:09.0 —1.3 +2.3 46°.

11-12 **1 Geminorum** 4.3, 6:00.8 +23-16.1, 10, +60° —3° Im: **A** 0:35.5 —1.8 +0.8 79°; **B** 0:36.7 —1.6 +1.2 69°; **C** 0:24.3 —1.9 +0.7 87°; **D** 0:25.4 —1.5 +1.4 70°; **E** 0:04.2 —1.2 +1.6 69°; **F** 23:42.8 —1.2 +0.9 89°.

11-12 **3 Geminorum** 5.8, 6:06.5 +23-07.4, 10, +82° +12° Im: **A** 3:58.4 —0.9 —3.6 140°; **B** 3:48.0 —1.2 —2.6 128°; **D** 3:46.7 —1.2 —3.6 140°; **G** 2:37.0 —1.4 +0.4 101°; **I** 2:23.6 —1.3 +0.8 97°.

17-18 **Nu Virginis** 4.2, 11:43.1 +6-49.9, 16, +74° —11° Im: **A** 3:24.3 —0.9 —1.0 146°; **B** 3:21.4 —0.9 —0.3 135°; **C** 3:26.4 —0.7 —2.3 165°; **D** 3:17.8 —0.7 —0.7 145°; **E** 3:16.0 —0.5 —2.1 166°. Em: **A** 4:31.6 —1.8 +1.0 271°; **B** 4:32.4 —1.5 +0.6 281°; **C** 4:17.2 —2.0 +2.5 251°; **D** 4:21.5 —1.5 +1.3 269°; **E** 3:58.2 —1.1 +3.1 243°; **G** 4:05.0 —0.2 +1.1 284°.

For selected occultations (visible at three or more stations in the U. S. and Canada under fairly favorable conditions), these predictions give: evening-morning date, star name, magnitude, right ascension in hours and minutes and declination in degrees and minutes, moon's age in days, limiting parallels of latitude, immersion or emersion; standard station designation, G.C.T., **a** and **b** quantities in minutes, position angle; the same data for each standard station westward.

Longitudes and latitudes of standard stations are:

A +72°.5, +42°.5	**E** +91°.0, +40°.0
B +73°.6, +45°.6	**F** +98°.0, +30°.0
C +77°.1, +38°.9	**G** +114°.0, +50°.9
D +79°.4, +43°.7	**H** +120°.0, +36°.0
I +123°.1 +49°.5	

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo — LoS**), and multiply **b** by the difference in latitude (**L — LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Greenwich civil time to your own standard time.

For additional occultations consult the **American Ephemeris and Nautical Almanac** and the British **Nautical Almanac**, from which these predictions are taken. Texas predictions were computed by E. W. Woolard and Paul Herget.

GREENWICH CIVIL TIME (GCT)

TIMES used on the Observer's Page are Greenwich civil or universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the GCT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.

R CORONAE BOREALIS FADING

Late in February, 1945, A.A.V.S.O. observations seemed to indicate that the interesting irregular variable star R, in the constellation of the Northern Crown, was about to descend to one of its real fadeaways, but by late March the star had decreased in brightness by only a magnitude and a half, instead of by four or five magnitudes. Immediately, the variable began to increase its light and attained full normal brightness of the 6th magnitude in July.

About November 1st, R again began to fade away, and recent observations—as late as December 17th—show that the star had dropped to magnitude 9.5, with the appearance of going still fainter. It is not unusual to have this greater loss of light follow a minor decrease in brightness. The star will certainly bear close attention, especially in view of its unfavorable situation in the sky, which requires late night or early morning observations.

LEON CAMPBELL
Recorder, A.A.V.S.O.

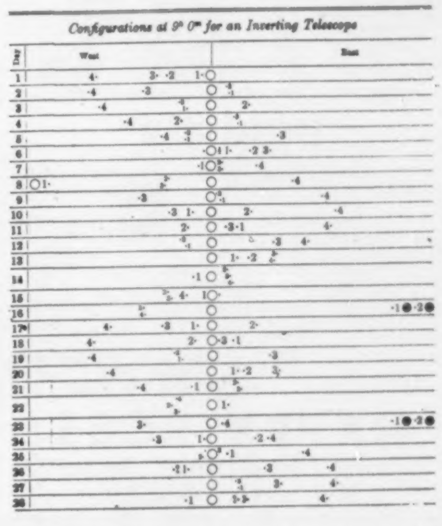
December 28, 1945

ALPHA AURIGIDS

One minor meteor shower is visible this month, the Alpha Aurigids, from February 5th to 10th. Slow, bright meteors are typical, but their rate of appearance is very low. E. O.

JUPITER'S SATELLITES

Jupiter's four bright moons have the positions shown below for the GCT given. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. Reproduced from the **American Ephemeris and Nautical Almanac**.



GLEANINGS FOR A. T. M.s

Correction Tolerances on Parabolic Mirrors

Lt. (jg) Paul E. Luce, formerly with the Optical Division, A.A.A., New York City, submits the accompanying charts for determining permissible variations from complete parabolic correction.

In figuring a parabolic mirror, there is a point beyond which it is unnecessary to carry the correction. This varies with the focal ratio (F/D) of the mirror, the tolerance being greater as the focal ratio increases. Indeed, the following discussion shows that for a focal ratio greater than f/11, a 6-inch spherical mirror is satisfactory. For larger diameter mirrors, the spherical-mirror focal ratio is greater, as will be seen.

The basic tolerance for optical perfection is the Rayleigh limit. Lord Rayleigh stated the empirical conclusion that an optical image would not differ sensibly from perfection if the rays composing it arrived over paths which did not differ from one another in length by more than one quarter of a wave length. Since no one has yet devised a suitable numerical measure of the perfection of an image, it is impossible to prove the truth of this conclusion mathematically, but experience indicates that it is an excellent criterion of performance for an optical system. In fact, it is a very strict criterion, and we are quite justified in adopting a small multiple of the Rayleigh limit as our tolerance for optical-path differences in an instrument. In the accompanying charts the tolerance is taken to be one half of a wave length; for supreme optical performance, we advise using half the tolerance here given.

Therefore, we adopt the requirement that the greatest difference of optical paths of the light forming a star image at the axial focus of our parabolic mirror shall not exceed one half a wave length. The wave length of the brightest part of the solar spectrum is 5500 angstroms, or about 0.00002 inch, and half of this is 0.00001 inch.

Now, if we have a perfect parabola, we know that, by definition, all optical paths to the axial focus are equal. Hence, if our parabola departs from perfection at the periphery by no more than half this, or 0.000005 inch (five millionths of an inch), the optical path differences will not be greater than twice the Rayleigh limit. The path difference is, of course, twice the departure of the mirror, when we consider both incident and reflected rays in this region.

Strictly speaking, we should measure the departure along a radius, but this would unnecessarily complicate the mathematical treatment and, since for the region surrounding the vertex the radial and axial departures are nearly the same, we take the axial departure without misgivings, since it is larger and will lead to a smaller tolerance.

It may be shown (see **Amateur Telescope Making**, page 257) that the axial departure of a parabola from a sphere is given by $e = D^4/1024\ F^3$, where D is

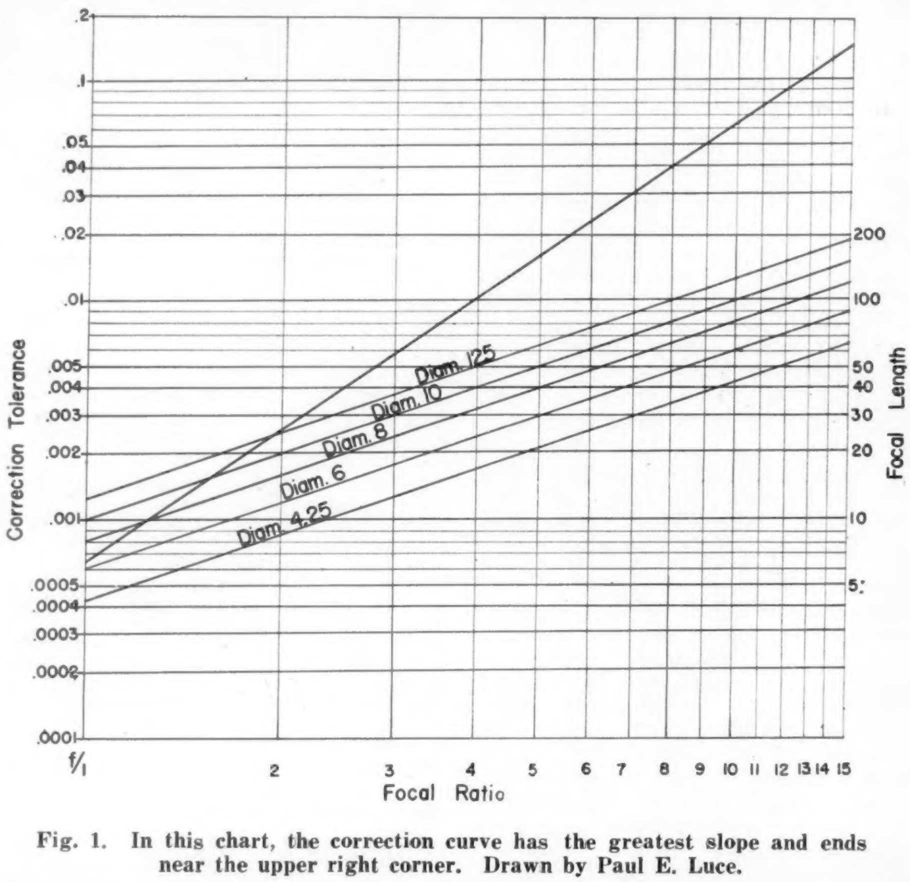


Fig. 1. In this chart, the correction curve has the greatest slope and ends near the upper right corner. Drawn by Paul E. Luce.

EDITED BY EARLE B. BROWN

the diameter of the mirror and F its focal length. This is the departure at the periphery, which will be the greatest if the curve has smooth progression. We allow ourselves, as above, 0.000005 inch, which is $0.000005 \times 100/e$ per cent of the total departure, e.

Substituting for e and solving, we obtain $T = 0.512\ f^2/D$, where T is the percentage of e we are allowed and f is the focal ratio.

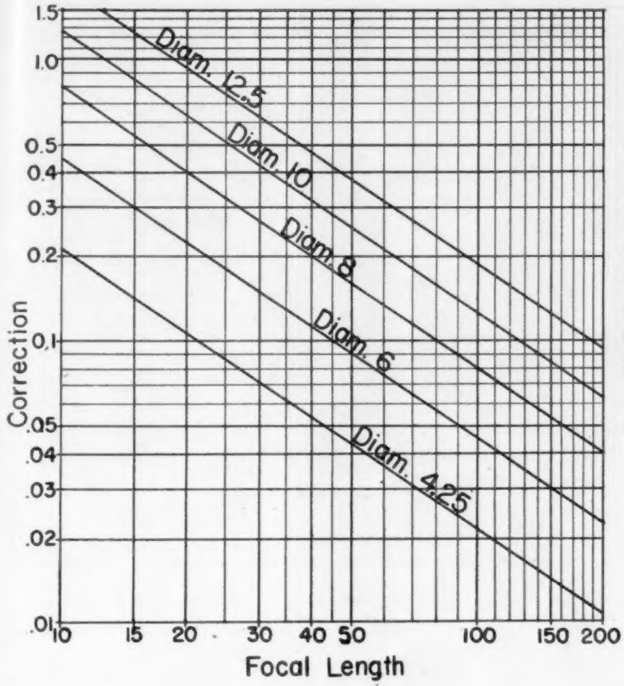


Fig. 2. As the curve for any mirror diameter is a straight line, the amateur may interpolate between those mirror diameters specified, if his mirror is of another size. The knife-edge tolerance is given in inches and fractions. Drawn by Paul E. Luce.

Now we must interpret this in terms of the correction as measured by the knife edge of the Foucault test. We shall consider the light source stationary, knife edge moving, with R the radius of curvature (2F) and r the zonal radius (D/2). Assuming that a given variation in the knife-edge position from what is called for by the formula r^2/R represents a proportionate departure from a true parabola, we apply the percentage tolerance, T, to the formula r^2/R, and obtain $t = r^2\ T/R = 0.00064\ f^2$.

For graphical representation, the knife-edge tolerance, t, is plotted against the focal ratio, f, in Figure 1. To eliminate the necessity for computing F, a series of lines representing various common mirror diameters in inches is plotted on the same chart. The heavy line with steepest slope is the correction curve.

If the focal ratio is known, enter the chart at the bottom margin with this value and read the knife-edge tolerance at the left margin, opposite the intersection of the correction curve with the vertical line corresponding to the focal ratio.

If the focal ratio has not been computed, enter the chart at the right-hand margin with the focal length, proceed along this horizontal line to the curve corresponding to the diameter, then vertically to the correction curve and read the tolerance at the left margin as before.

The chart in Figure 2 gives the values of r^2/R on the left margin for focal lengths as given on the lower margin.

The knife-edge tolerance, t, is given in the charts in inches, not as a percentage of r^2/R. It is interesting to note that the linear value of the tolerance depends only upon the focal ratio and

not upon the diameter. This, of course, is only the mathematical statement of the fact that the mirror must be figured to five millionths of an inch at the edge, regardless of its size.

The charts, it will be noted, are plotted on logarithmic co-ordinates, since when this is done the curves are reproduced as straight lines, and it is a simple matter for the user to interpolate an additional line for a mirror diameter not given on the charts.

IN FOCUS

(Continued from page 2)

Another excellent source of information on lunar features is W. Goodacre's map of the moon and the accompanying description of 522 named objects which appears with his map in **Splendour of the Heavens.** We have used Goodacre's data and the sources mentioned above in compiling the following descriptions. Some of the objects on this month's chart will appear again later, and be described at that time.

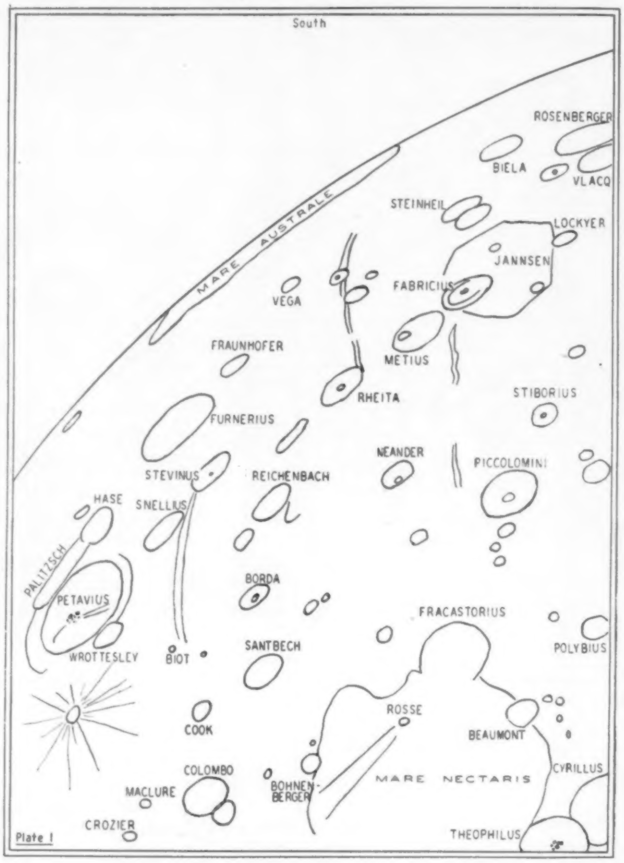


Plate I

Beaumont. A 30-mile ring plain with eroded walls. It is named after a French geologist born in 1798.

Biela. A 45-mile ring plain, with 14-mile Biela **C** in its northwest wall. Wilhelm von Biela (1782-1856) was an Austrian army officer who fought against Napoleon. In 1826, he discovered the comet named after him, and calculated its orbit.

Colombo. Indistinct on the photograph is this 47-mile ringed plain. It was named after Christopher Columbus by Maedler.

Cook. Named after James Cook, the famous explorer, this 27-mile ring plain is notable for its dark interior.

Crozier. A small ringed plain named after a naval captain. With MacClure, Colombo, Cook, and other nearby features, the region has been referred to as the "navigators' corner."

Fabricius. A deep ring plain about 50 miles across. The large adjoining feature to the southwest is Fabricius **A,** with Fabricius **B** the crater southwest of this. Dutch amateur astronomer Fabricius discovered Mira to be a variable, in 1596.

Fracastor (preferred I.A.U. spelling). This 60-mile area is not fully enclosed.

Fraunhofer. A ring plain whose walls rise about 5,000 feet above the interior, named for the famous optical worker and discoverer of the dark lines in the spectrum of the sun (1814).

Furnerius. Although indistinct at this phase, this is a good-sized walled plain, whose mountains rise about 11,000 feet.

Janssen (preferred I.A.U. spelling). The large hexagonal enclosure includes Fabricius; it is 120 miles in extent. Janssen was a famous French astronomer; in 1868, he observed solar prominences without an eclipse.

MacClure (preferred I.A.U. spelling). Named for a 19th-century English naval officer and arctic explorer.

Mare Australe. The southern sea, named by Maedler.

Mare Nectaris. The sea of nectar, named by Riccioli.

Neander. A 34-mile ring plain with walls as much as 8,000 feet high. Note the bright central peak; also, the 7-mile wide crater **A** in the rim.

Piccolomini. A ring plain, with walls rising from 9,000 to 14,000 feet above the interior, and a central mountain. Alessandro Piccolomini (1508-1578) was archbishop of Sienna; his star maps were the first to designate stars by Latin letters.

Reichenbach. A 40-mile plain named after a German artillery officer who in 1804 founded an optical shop in Munich, where Fraunhofer joined him later.

Rheita. A ring plain 40 miles across, named for the birthplace of a Bohemian optician who invented the terrestrial eyepiece. The Rheita valley extends southward from this feature.

Rosse. This deep and conspicuous crater in Mare Nectaris, eight miles across, was named for the Earl of Rosse (1800-1867).

Snellius. The feature is almost obliterated by the brightness of the region at this phase. Willibrord Snell (1591-1626) discovered the law of refraction of light.

Steinheil. Although Maedler considered this a double ring plain, the I. A. U. calls the southwestern part Watt, and the northeastern ring Steinheil. Steinheil was a German physicist and telescope maker; Watt invented the steam engine.

UNUSUAL WAR BARGAINS in LENSES and PRISMS

NOW! MAKE YOUR OWN BINOCULARS!

Complete Set of LENSES and PRISMS from Navy's 7 x 50 Model
SAVE UP TO $150.00!

Here's an unusual opportunity to secure a fine set of Binoculars . . . at a tremendous saving of money. Build them yourself with all of the very same optics (no metal parts) contained in the Navy's 7 Power Glasses . . . the Binoculars which received such wide acclaim during the war. Depending on your choice, you may buy a perfect set of Lenses and Prisms for the Binocular construction job, or a set of seconds (exactly the same units, but Lenses are uncemented and have slight imperfections). If, however, you wish to construct a Monocular (½ a Binocular) you may do so, choosing either perfect components or seconds. The Monocular sets comprise ½ quantities of the same optics required for the Binocular. The full Binocular set comprises the following:— 2 Cemented Achromatic Eye Piece Lenses, 17.5 mm. diam; 2 Eye Field Lenses; 4 Porro Prisms; 2 Cemented Achromatic Objective Lenses, diam. 52 mms. Complete assembly directions included.

Stock No. 5102-Y — Perfect Binocular Set .... **$25.00 Postpaid**
Stock No. 5103-Y — Perfect Monocular Set .... **$12.50 Postpaid**
Stock No. 5105-Y — Seconds for Binoculars .... **$11.00 Postpaid**
Stock No. 5104-Y — Seconds for Monocular .... **$5.50 Postpaid**

All Items Finely Ground and Polished but Edges Slightly Chipped or Other Slight Imperfections Which We Guarantee Will Not Interfere with Their Use. Come Neatly Packed and Marked.

TO KEEP POSTED on all our new Optical Items, send 10c and your name and address to get on our regular "Flash" mailing list.

35 MM. KODACHROME PROJECTING LENS SET—Consists of Achromatic Lens for projecting, plus a Condensing Lens and piece of Heat Absorbing Glass with directions.
Stock No. 4025-Y .... **$1.95 Postpaid**

SPECTROSCOPE SETS . . . These sets contain all Lenses and Prisms you need to make a Spectroscope plus FREE 15-page Instruction Booklet.
Stock No. 1500-Y—Hand Type Spectroscope, **$3.45 Postpaid**
Stock No. 1501-Y—Laboratory Type Spectroscope .... **$6.50 Postpaid**

MICROSCOPE SETS

Consisting of two Achromatic Lenses and two Convex Eye Piece Lenses which you can use to make a 40 Power Pocket Microscope, or 140 Power Regular Size Microscope. These color corrected Lenses will give you excellent definition.
Stock No. 1052-Y .... **$3.00 Postpaid**

Consisting of Prism, Mirror and Condensing Lens. These used together with Stock No. 1052-Y will make an excellent Microprojector enabling you to get screen magnification of 400 to 1000 Power according to screen distance.
Stock No. 1038-Y .... **$2.00 Postpaid**

SPECIALS IN LENS SETS

Set No. 1-Y — "Our Advertising Special" — 15 lenses for $1.60 Postpaid, plus 10-page idea booklet. For copying, ULTRA CLOSE-UP SHOTS macro-photography, experimental optics, magnifying and for making a two power f/16 Telephoto Lens, "Dummy Camera," Kodachrome Viewer, DETACHABLE REFLEX VIEW-FINDER for 35 mm. cameras, stereoscopic viewer, ground glass and enlarging focusing aids, TELESCOPES, low power Microscopes and for many other uses.

NEW 50-PAGE IDEA BOOK "FUN WITH CHIPPED EDGE LENSES"
Contains wide variety of projects and fully covers the fascinating uses of all Lenses in sets listed above . . . only **$1.00 Postpaid.**

RETICLE SET—5 assorted, engraved reticles from U. S. Gunsights. **Stock No. 2035-Y..$1.00 Postpaid**

OPTICS FROM 4-POWER PANORAMIC TELESCOPE
Excellent condition. Consists of Objective Prism, Dove Prism, Achromatic Objective Lens, Amici Roof Prism, Eye Lens Set (. . . a $60.00 value).
Stock No. 5016-Y .... **$6.00 Postpaid**

TELESCOPE EYE PIECE SET—Consists of perfect Eye Lens Set from a Govt. Telescope. Diam. 1 inch, Focal Length 1 inch.
Stock No. 6144-Y .... **$1.00 Postpaid**

MAGNIFIER SET—5 magnifying Lenses—Powers from 1 to 10.
Stock No. 1026-Y.......... **$2.00 Postpaid**

RAW OPTICAL GLASS

An exceptional opportunity to secure a large variety of Optical Pieces both Crown and Flint glass (seconds) in varying stages of processing. Many prism blanks.
Stock No. 703-Y—8 lbs. (min. wt.)—**$5.00 Postpaid**
Stock No. 702-Y—1½ lbs. .... **$1.00 Postpaid**

ALL THE LENSES YOU NEED TO MAKE YOUR OWN TELESCOPE!
ALL ARE ACHROMATIC LENSES

GALILEAN TYPE — Simplest to Make but has Narrow Field of View.

Stock No. 5018-Y—4 Power Telescope, **$1.25 Postpaid**

Stock No. 5004-Y—Small 2 Power Pocket Scope .... **$1.00 Postpaid**

PRISM TELESCOPES—Use Prism instead of Lenses to Erect Image. Have wide field of view.

Stock No. 5010-Y—6 Power Telescope, **$3.00 Postpaid**

Stock No. 5012-Y—20 Power Telescope, **$7.25 Postpaid**

ACHROMATIC LENSES

Stock No.	Dia. in mms.	F.L. in mms.	Price
6158-Y*	18	80	$1.00
6159-Y*	23	51	1.25
6161-Y	24	48	1.25
6162-Y	25	122	1.25
6164-Y*	26	104	.80
6165-Y	27	185	1.00
6166-Y	29	54	1.25
6168-Y	29	76	1.25
6169-Y	31	122	1.50
6171-Y	32	171	1.00
6173-Y*	34	65	1.00
6176-Y*	38	131	1.00
6177-Y*	39	63	1.10
6178-Y*	45	189	1.50
6179-Y*	46	78	1.25

*ASTERISKED ITEMS are uncemented, but FREE cement and Directions included with uncemented sets.

USES:—Use these Lenses for making Projecting Lenses, Low Power Microscope Objectives, corrected Magnifiers, substitute enlarging Lenses, Eye-Piece Lenses, Macro-photography, Gadgets, Optical Instruments, etc., etc.

CLEANING BRUSH SET . . . For Lenses, Optical instruments, etc. Perfect quality—12 inch Flexible Plastic handle, hollow circular const. Range from stiff to very soft. 4 Brushes to set.
Stock No. 504-Y—(Reg. $6.00 value)..Price $1.00

RIGHT ANGLE PRISM—Flint Optical Glass, size 41 mm. by 91 mm. by 64 mm. Use in front of camera Lens to take pictures to right or left while pointing camera straight ahead. Also used in front of camera Lens to reverse image in direct positive work. Two of these Prisms will make an erecting system for a Telescope.
Stock No. 3076-Y .... **$3.00 Postpaid**

LENS CLEANING TISSUE—In spite of paper shortage, we offer an exceptional bargain in first quality Lens Cleaning Tissue. You get 3 to 4 times as much tissue as when you buy in the ordinary small booklets. One ream—480 sheets—size 7 ¾" x 10¾".
Stock No. 704-Y .... **$1.50 Postpaid**

REMARKABLE VALUE!

$141.01 Worth of Perfect Lenses for Only $10.00
Complete System from Artillery Scope (5X).
9 Lenses, low reflection coated, **absolutely Perfect.** Diameter range from 1 1/3 inches to 2 1/5 inches. Used for making Telescopes and hundreds of other uses.
Stock No. 5019-Y .... **$10.00 Postpaid**

BIG DOUBLE CONVEX LENS—74 mm. diam., 99 mm. F.L. Weighs 9 oz. Made of borosilicate Crown Optical Glass. Used as spotlight Lens, Condensing Lens, etc.
Stock No. 1048-Y .... **$1.50 Postpaid**

BIG DOUBLE CONCAVE LENS—74 mm. diam., 110 mm. F.L. Made of extra dense Flint. Used as reducing Lens, for trick photography, etc.
Stock No. 1049-Y .... **$1.00 Postpaid**

MISCELLANEOUS ITEMS

Stock No.	Item	Price
2024-Y	10 Pieces Circular A-1 Plate Glass (Diam. 31 mm.—for making Filter)	.25
523-Y	Six Threaded Metal Reticle Cells	.25
624-Y	Neutral Ray Filter, size 4¾" x 2½"	.25
3022-Y	Round Wedge, 65 mm. Diam. Each.	5.00
3021-Y	Amici Roof Prism (3rd grade). Each	.25
16-Y	Level Vial, 48 mm. long	.20
1030-Y	2" Diam. Reducing Lens. Each	.25
1031-Y	Perfect 6 Power Magnifier, Diam. 28 mm.	.25

(Minimum Order on Above—$1.00)

PLAIN OR SILVERED TANK PRISM—90-45-45 deg. 5¾" long, 2⅛" wide, finely ground and polished. Would normally retail from $24 to $30 each. **Stock No. 3005-Y** (Plain Prism) or **Stock No. 3004-Y** (Silvered) . . . **$2.00 each Postpaid. FOUR TANK PRISMS**—Special—**$7.00 Postpaid.**

TANK PERISCOPE

Complete Set Mounted Components

Rugged, strong, originally constructed for U. S. Tank Corps. Consists of 2 fine Periscope Mirrors mounted in metal and plastic. Perfect condition. Would normally retail at $40 to $50. **Stock No. 700-Y . . . $2.00 Complete Set Postpaid.**

PRISMS

Stock No.	Type	Base Width	Base Length	Price
3040-Y	Right Angle	33 mms.	23 mms.	$1.00
3045-Y	Right Angle	70 mms.	168 mms.	8.00
3001-Y	Lens Surface	20 mms.	14 mms.	2.00
3006-Y	Porro-Abbe	9 mms.	9 mms.	.25
3009-Y	Porro	52 mms.	25 mms.	1.00
3010-Y	Porro	43 mms.	21 mms.	.50
3016-Y	Pentagon	45 mms.	22 mms.	.75
3029-Y	Dove	16 mms.	65 mms.	1.25
3036-Y	80 Degree Roof	60 mms.	36 mms.	4.00
3049-Y	Right Angle	69 mms.	167 mms.	10.00
3047-Y	Right Angle	53 mms.	103 mms.	4.00
3038-Y	Roof Prism	18 mms.	34 mms.	2.50

ORDER BY SET OR STOCK NO. • SATISFACTION GUARANTEED • IMMEDIATE DELIVERY

EDMUND SALVAGE COMPANY + P. O. AUDUBON, NEW JERSEY

ASTRONOMICAL ANECDOTES

(*Continued from page* 6)

live in temperate zones; *periscians* are inhabitants of frigid zones. In other words, amphiscians can have their shadows cast both to the north and south; ascians have no shadows at all; periscians' shadows move entirely around (during summer); heteroscians live between the amphiscians and periscians.

You've all heard of the antipodes — the points directly opposite on the earth, on the opposite meridian and on the parallel with the same number but opposite sign. But how about the *antoeci*, with the same meridian but opposite parallel, and the *perioeci*, with same parallel but opposite meridian? I hadn't either. R.K.M.

COSMOGONICAL IMPLICATIONS OF THE ATOMIC BOMB

(*Continued from page* 10)

Our result turns out to be 10^{24} atmospheres, whereas Fermi-Dirac statistics give 10^{28}. If the attraction between the neutrons were also considered, the actual pressure should be even smaller than 10^{24} atmospheres, giving us a favorable approach to the problem of accounting for the high densities in the white dwarfs. If the temperature of a neutron core is reduced by loss of energy, the core may be converted into a liquid state, because of the attractive forces between pairs of nearest-neighbor neutrons.

(*To be continued*)

SWARTHMORE ASTRONOMER DIES

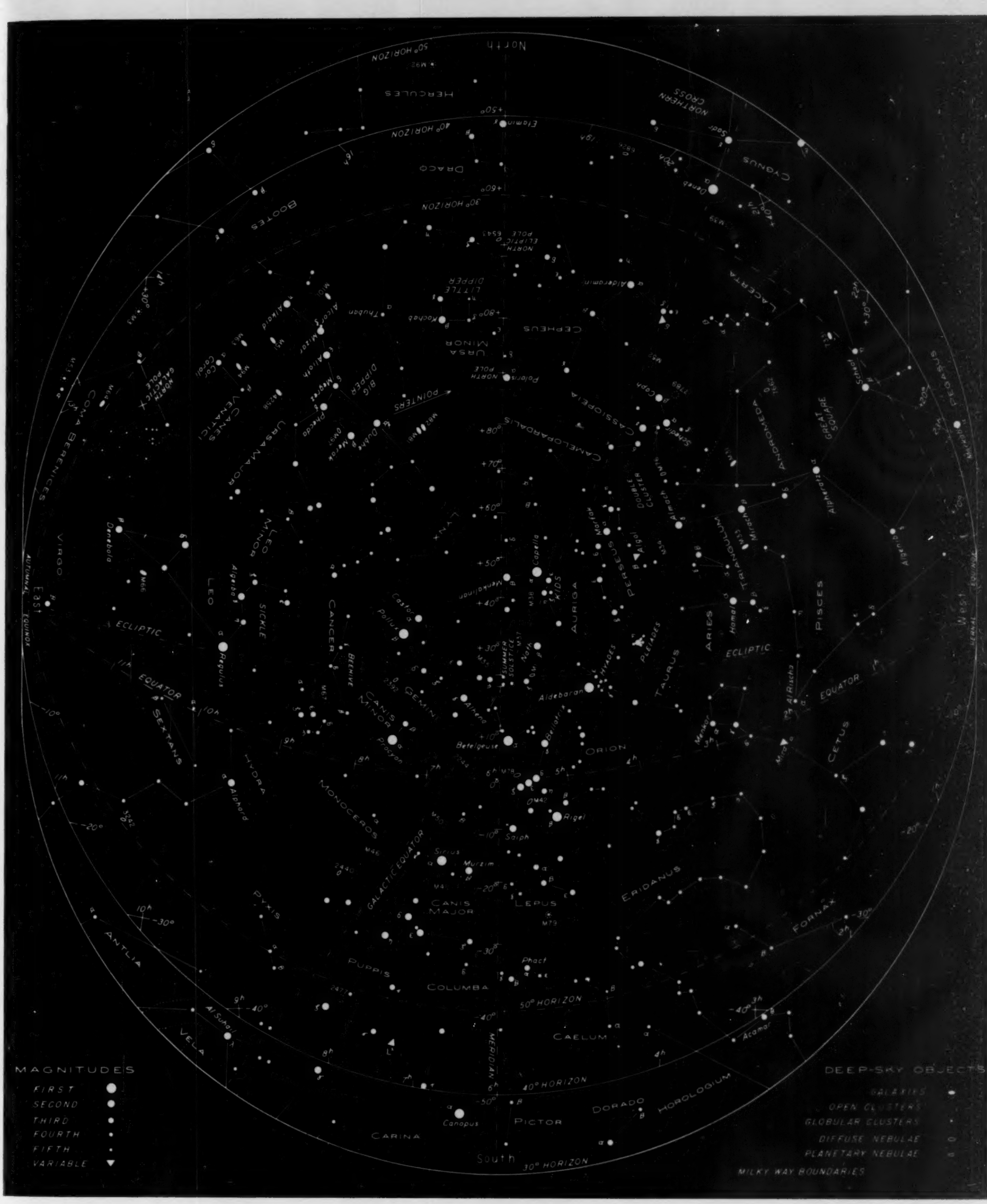
On December 23, 1945, at the age of 52, Dr. Hans Fried, lecturer in mathematics at Swarthmore College, died suddenly at his home in Lansdowne, Pa. Dr. Fried was a teacher in Vienna until 1939; he came to the United States in 1940 and from September, 1941, until November, 1943, he was assistant in the Sproul Observatory at Swarthmore.

HERE AND THERE WITH AMATEURS

This is not intended as a complete list of societies, but rather to serve as a guide for persons near these centers, and to provide information for transplanted amateurs who may wish to visit other groups. The asterisks denote societies whose members receive *Sky and Telescope* as a privilege of membership.

City	*Organization*	*Date*	*P.M.*	*Season*	*Meeting Place*	*Communicate with*
BOSTON	*Bond Ast. Club	1st Thu.	8:15	Oct.-June	Harvard Obs.	Miriam Bond, Harvard Observatory
"	*A.T.M.s of Boston	2nd Thu.	8:00	Sept.-June	Harvard Obs.	A. G. Hall, 206 Maplewood St., Watertown
BROOKLYN, N.Y.	Astr. Dept., B'klyn Inst.	Rd. Table 3rd Thu.	8:15	Oct.-April	Brooklyn Inst.	William Henry, 154 Nassau St., N. Y. C., *BA.* 7-9473
BUFFALO	A.T.M.s & Observers	1st, 3rd Fri.	8:00	Oct.-June	Mus. of Science	J. J. Davis, Museum of Science
CHATTANOOGA	Barnard A. S.	4th Fri.	7:30	All year	Chattanooga Obs.	C. T. Jones, 302 James Bldg., *CHat.* 7-1936
CHICAGO	*Burnham A. S.	2nd Tue.	8:00	Sept.-June	Chi. Acad. of Sciences	Miss W. Sawtell, 928 N. Harvey, Oak Park
CINCINNATI	*Cin. A. A.	2nd Fri.	8:00	Sept.-June	Cincinnati Obs.	Dan McCarthy, 1622 DeSales Lane
CLEVELAND	Cleveland A. S.	Fri.	8:00	Sept.-June	Warner & Swasey Obs.	Virginia Burger, Warner & Swasey Obs.
DAYTONA BEACH	D. B. Stargazers	Alt. Mon.	8:00	Nov.-June	500 S. Ridgewood Ave.	Rolland E. Stevens, 500 S. Ridgewood
DETROIT	*Detroit A. S.	2nd Sun.	3:00	Sept.-June	Wayne U., Rm. 187	E. R. Phelps, Wayne University
"	*Northwest A. S.	3rd Tue.	8:00	Sept.-June	Redford High Sch.	E. P. Holleran, 12305 Turner Ave.
DULUTH, MINN.	Duluth Ast. Club	Meetings suspended				Ray S. Huey, 1822 E. 3rd St.
FT. WORTH	Tex. Observers	No regular meetings				Oscar E. Monnig, 1010 Morningside Dr.
GADSDEN, ALA.	Ala. A. A.	1st Thu.	7:30	All year	Ala. Power Audit.	Brent L. Harrell, 1176 *W* or 55
GENEVA, ILL.	*Fox Valley A. S.	3rd Tue.	8:00	....	Geneva City Hall	Wm. Siekman, Woodlawn Ave., Batavia
HOUSTON	*Houston A. S.	Last Fri.	7:30	All year	Mus. Nat. Hist. Annex	Nathan Miron, 4310 Elsbury
INDIANAPOLIS	Indiana A. A.	1st Sun.	2:15	All year	Odeon Hall	E. W. Johnson, 808 Peoples Bank Bldg.
JOLIET, ILL.	Joliet A. S.	Alt. Tue.	8:00	Oct.-May	Jol. Mus. & Art Gall'y	Mrs. Robert L. Price, 403 Second Ave.
LOS ANGELES	L.A.A.S.	2nd Thu.	8:15	....	2606 W. 8th St.	A. M. Newton, 2606 W. 8th St.
LOUISVILLE, KY.	L'ville A. S.	1st Tue.	8:00	Sept.-May†	University Center, Univ. of Louisville	B. F. Kubaugh, 621 S. 34th St.
MADISON, WIS.	Madison A. S.	2nd Wed.	8:00	All year	Washburn Obs.	Dr. C. M. Huffer, Washburn Obs.
MEMPHIS	A.T.M.s of Mem.	Meetings suspended				R. E. Wendt, Jr., 2084 Linden Ave.
MIAMI, FLA.	Southern Cross A.S.	Every Fri.	7:30	All year	M. B. Lib. Grounds	A. P. Smith, Jr., 426 S.W. 26th Road
MILWAUKEE	Milw. A. S.	1st Thu.	6:15	Oct.-May††	City Club	E. A. Halbach, 2971 S. 52 St.
MOLINE, ILL.	*Pop. Ast. Club	Wed.†††	7:30	Feb.-Nov.	Sky Ridge Obs.	Carl H. Gamble, Route 1
NEW HAVEN	New Haven A.A.S.	4th Sat.	8:00	Sept.-June	Yale Obs.	J. J. Neale, 29 Fairmont Ave.
NEW ORLEANS	A.S. of N. Orleans	Last Wed.	8:00	Sept.-May	Cunningham Obs.	Dr. J. Adair Lyon, 1210 Broadway
NEW YORK	*A.A.A.	1st, 3rd Wed.	8:15	Oct.-May	Amer. Mus. Nat. Hist.	G. V. Plachy, Hayden Plan., *EN.* 2-8500
"	Junior Ast. Club	1st, 3rd Fri.	8:00	Oct.-May	Amer. Mus. Nat. Hist.	J. B. Rothschild, Hayden Plan., *EN.* 2-8500
NORFOLK, VA.	A.A.S. of Norfolk	2nd Thu.	8:00	All year	635 W. 29th St.	P. N. Anderson, 635 W. 29th St.
NORWALK, CAL.	Excelsior Tel. Club	Thu.	7:00	All year	Excelsior Union H. S.	Geo. F. Joyner, 410 Sproul St.
NORWALK, CONN.	Norwalk Ast. Soc.	Last Fri.	8:00	Sept.-June	Private houses	Mrs. A. Hamilton, 4 Union Pk., 6-5947
OAKLAND, CAL.	*Eastbay A. A.	1st Sat.	8:00	Sept.-June	Chabot Obs.	Miss H. E. Neall, 6557 Whitney St.
OWENSBORO, KY.	*Owensboro A. C.	3rd Sat.	8:00	All year	Public Library	Fred Rutley, 129 W. 19th St.
PHILADELPHIA	A. A. of F. I.	3rd Fri.	8:00	All year	The Franklin Inst.	Edwin F. Bailey, *Rit.* 3050
"	*Rittenhouse A. S.	2nd Fri.	8:00	Oct.-May	The Franklin Inst.	A. C. Schock, *Rit.* 3050
PITTSBURGH	*A.A.A. of P'burgh	2nd Fri.	8:00	Sept.-June	Buhl Planetarium	Louis E. Bier, 837 Estella St.
PONTIAC, MICH.	*Pontiac A.A.A.	2nd Thu.	8:00	All year	Private homes	Harvey E. Orser, 34 Pine St.
PORTLAND, ME.	A.S. of Maine	2nd Fri.	8:00	All year	Private homes	H. M. Harris, 27 Victory Ave., S. Portland
PORTLAND, ORE.	*Ast. Study Group	1st Tue.	8:00	All year	309 Public Serv. Bldg.	H. J. Carruthers, 427 S. E. 61 Ave.
PROVIDENCE, R. I.	Skyscrapers, Inc.	Mon. or Wed.	8:00	All year	Ladd Observatory	Ladd Obs., Brown U., *GA.* 1633
RENO, NEV.	A.S. of Nev.	4th Wed.	8:00	All year	Univ. of Nevada	G. B. Blair, University of Nevada
ROCHESTER, N. Y.	Roch. Ast. Club	Alt. Fri.	8:00	Oct.-May	Univ. of Rochester	M. L. Groff, 400 University Ave.
SACRAMENTO	Sac. Val. A. S.	....	8:00	All year	Sacramento College	S. J. Smyth, 246 41st St.
SAN DIEGO, CAL.	Ast. Soc. of S. D.	1st Fri.	7:30	Oct.-June	504 Elec. Bldg.	R. M. Lippert, Box 41, N. Park Sta.
SCHENECTADY	S'tady Ast. Club	Meetings suspended				C. H. Chapman, 216 Glen Ave., Scotia
SOUTH BEND, IND.	St. Joseph Val. Ast.	Last Tue.	8:00	All year	928 Oak St.	F. K. Czyzewski, South Bend Tribune
TACOMA, WASH.	Tacoma A.A.	Meetings suspended				Grant Burke, Route 3, Box 349
TULSA, OKLA.	Tulsa A.S.	Occasional meetings				V. L. Jones, 4-8462
WASHINGTON, D.C.	Nat'l. Cap. A.A.A.	1st Sat.	8:00	Oct.-June	U. S. Nat'l. Museum	Mrs. Wm. Harris, 4315 Chesapeake, N.W.
WICHITA, KANS.	*Wichita A.S.	2nd Tue.	8:00	All year	E. High Sch., Rm. 214	S. S. Whitehead, 2322 E. Douglas, 33148
WORCESTER, MASS.	*Aldrich Ast. Club	2nd Tue.	7:30	All year	Mus. Natural History	Ruth Foley, 9 Oberlin St., 63101
YAKIMA, WASH.	Yak. Am. Ast'mers	3rd Tue.	7:30	All year	Chamb. of Comm. Bldg.	C. A. Zumwalt, 1019 Pleasant

†June, Jul., Aug., informal meetings. ††Dinner meeting. †††Nearest 1st-quarter moon.



DEEP-SKY WONDERS

SPECIAL objects for your February telescopic observing are listed here, some of which do not appear on the chart above. Norton designations are in parentheses.

Lynx. NGC 2683 (200′), 8^h $49^m.6$, +33° 38′; spiral. Forerunner of the galactic host of spring and early summer.

Puppis. NGC 2438, 7^h 39^m, —14° 35′; planetary, oval shaped, 68″ in diameter. In a handsome cluster of 150 stars, M46, and near its northern border. NGC 2539 (11′), 8^h 6^m, —12° 32′; cluster of 150 stars. NGC 2482, 7^h $50^m.7$, —24° 02′; cluster of 50 stars, and M93, 7^h $40^m.4$, —23° 38′; cluster of 60 stars.

If local observing conditions make these three difficult, look in the same constellation for the beautiful cluster of 300 stars, NGC 2477, 7^h $48^m.7$, —38° 17′, and its neighbor, NGC 2451, which precedes it by nine minutes. Both are between Zeta and Pi.

L. S. COPELAND

STARS FOR FEBRUARY

from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. When facing north, hold "North" at the bottom, and similarly for other directions. This is a stereographic projection, in which the flattened appearance of the sky itself is closely reproduced, without distortion.